ARVOR-I & DO-I FLOAT – 33-16-033_UTI

USER MANUAL

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USER MANUAL

DOC33-16-033 du 07 / 01 / 20 rev.11

DATE	REVISION	OBJET	Auteur
07/01/16	0	Creation	JS
06/03/16	1	SBD Packet format modification	JS
06/07/16	2	SBD packet format modification	JS
23/01/17	3	“In Air” measurement and ice detection functions added	JS
01/03/17	4	Min & max values for mission commands added	JS
24/03/17	5	Pressure coding format correction, ice detection strategy added. CTDO packet format added	JS
30/03/17	6	Tech packet 1 & 2 format corrections	JS
19/04/17	7	Optode temperature coding correction	JS
24/08/17	8	Review of the document and update of Annex B (according to Coriolis decoder version ‘013a’ for Coriolis float version 5.45)	JPR
19/11/18	9	Resolution of TC0 (p55) / offset of internal vacuum (p46)	DN
19/07/19	10	Deployment on pressure detection and descent speed configurable	DN
07/01/20	11	Precisions about Parameters packets are only sent on first session and on telecommands receiving	DN

1 INTRODUCTION

ARVOR is a subsurface profiling float developed jointly by IFREMER and MARTEC Group. Since January 1st, 2009 **nke** has integrated profiling floats activity and is now in charge of ARVOR-I manufacturing and development in industrial partnership with IFREMER.

ARVOR-I is the Iridium version of ARVOR float (that uses ARGOS satellite system for data transmission), from which it takes up most of the essential sub-assemblies.

The ARVOR-I float described in this manual is designed for the ARGO Program. This international program will be a major component of the Global Ocean Observing System (GOOS). An array of 3,000 free-drifting profiling floats is planned for deployment in 2004. These floats will measure the temperature and salinity of the upper 2,000 meters of the ocean, allowing continuous monitoring of the ocean's climate.

All Argo measurements will be relayed and made publicly available within hours after collection. The data will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability, including heat and freshwater storage and transport. It is expected that ARGO data will be used for initialization of ocean and coupled forecast models, and for dynamic model testing. A primary focus of Argo is seasonal to decadal climate variability and predictability.

After launch, ARVOR-I's mission consists of a repeating cycle of descent, submerged drift, ascent and data transmission. During these cycles, ARVOR-I dynamically controls its buoyancy with a hydraulic system. This hydraulic system adjusts the density of the float causing it to descend, ascend or hover at a constant depth in the ocean. The user selects the depth at which the system drifts between descent and ascent profiles. ARVOR-I continually samples the pressure at this drift depth and maintains that depth within approximately 30m.

After the submerged drift portion of a cycle, the float proceeds to the depth at which the ascending profile is to begin. The ascent profile starting depth (typically the ARGO-selected depth of 2,000m) is not necessarily the same as the drift depth.

During its mission, ARVOR-I collects measurements of four parameters - salinity, temperature and depth (CTD) – (with dissolved oxygen as optional sensor) and saves them in its memory. These measurements can be made during the float descent (descent profile), during the submerged drift period (Lagrangian operation) and during the ascent (ascent profile).

After each ascent, ARVOR-I transmits its saved data to the satellites of the IRIDIUM system. The volume of data is reduced using a compression algorithm in order to reduce the number of Iridium messages to transmit. The IRIDIUM system calculates the float's position during its stay on the sea surface.

In 2013, nke developed new firmware evolutions for sampling capacity increasing, reliability improvement during all float life phases, and introduce possibility to program 2 Mission schemes (2 cycle period, with associated Parking and Profile Depth) (see figure Figure 8 : Cycle period description on page 37 for more details about cycle possibilities).

By this way, ARVOR float can realized specific cycle program closed to deployment area, and then switch to a classical ARGO program.

In 2016, nke developed new firmware evolutions for “In Air” measurement, and added ice detection function.

This manual describes the ARVOR-I float, how to use it and safety precautions to be observed during handling.

Please read this manual carefully to ensure that ARVOR-I functions as intended.

Overview of the present manual's contents:

- Chapter 2 contains the instructions necessary for the personnel in charge of the deployment
- Chapter 3 describes the components of ARVOR-I; it is intended for those who want a more in-depth understanding of ARVOR-I
- Chapter 4 describes the mission of ARVOR-I
- Chapter 5 describes the various parameters
- Chapter 6 describes the various IRIDIUM messages
- Chapter 7 presents the technical specifications
- Chapter 8 provides explanations about the operation of ARVOR-I
- Chapter 9 specifies the elements of the constraints limited to the transport of Lithium batteries.

2 OPERATING INSTRUCTIONS

The following instructions tell you how to handle, configure, test and launch the ARVOR-I float. Please read these instructions carefully and follow them closely to ensure your ARVOR-I float functions as intended.

2.1 Handling precautions

ARVOR-I is designed to withstand submersion at great depths for long periods of time (up to five years). This remarkable specification in oceanographic instrumentation is possible thanks to the protection of the casing by an anti-corrosion coating. This coating is sensitive to impact. Damage to the coating can accelerate the corrosion process.

NOTE: Take precautions to preserve the anti-corrosion coating during handling. Remove the float from its packing only when absolutely necessary.

NOTE: Regulations state that ARVOR-I must not be switched on during transport.

2.2 Acceptance tests

Immediately upon receipt of the ARVOR-I float, you should test it to confirm that it is complete, correctly configured and has not been damaged in shipment. If your ARVOR-I float fails any of the following tests, you should contact **nke instrumentation**.

2.2.1 Inventory

The following items should be supplied with your ARVOR-I float:

- The present user manual
- A test sheet
- Quickstart & Deployment checklist

NOTE: Disassembly of the float voids the warranty.

Check that all of the above items are present. If any are missing, contact **nke-instrumentation**.

2.2.2 Physical inspection

Upon the opening of the transport casing, visually inspect the float's general condition: Inspect the transport container for dents, damage, signs of impact or other signs that the float has been mishandled during shipping.

Inspect the CTD sensor, Oxygen sensor (optional) antenna, hull, housing around the lower bladder for dents or any other signs of damage

NOTE: Ensure the magnet is in place against the hull (on ON/OFF position), meaning that float is switched OFF.

2.3 Default parameters

Notwithstanding special instructions given to NKE during the ARVOR-I preparation stage, the following set of parameters is applied: **section 5 ARVOR-I PARAMETERS**.

If these parameters are not appropriate, the user can change them himself by following the instructions.

2.3.1 ARGO identification

The user is responsible for contacting the AIC in order to obtain the WMO number which will identify the ARVOR-I's mission

2.3.2 Decoding

The CORIOLIS project team (IFREMER) is able to assist the teams that use ARVOR-I for data processing.

Nke can provide light PC software for manual data decoding. Contact **nke-instrumentation**.

2.4 Manual Launching

Following is what you should do to launch the ARVOR-I float.

2.4.1 Test the float and arm the mission

Before you take ARVOR-I on deck for deployment, we recommend that you repeat all of the tests described in **section 2.5.8 "Display Sensor Data"**. This will ensure that the float is functioning and configured correctly and maximize the probability of success of your experiment.

IMPORTANT: Before launching the float, you must arm the mission by issuing the !AR command:

!AR

ARVOR-I will execute auto-test (see section 2.6.8 page 20 for description) and respond :

<AR ON>

Put the magnet on the float (ON/OFF position).

NOTE: Once the mission is armed, the next time you will attempt to communicate with the float upon magnet removal, you need to establish Bluetooth connection (see section 2.6.2 page 15) and press "ENTER" within 50 seconds after 5 pump activations in order to get the prompt].

2.4.2 Remove protective plugs and magnet

The pump system of the CTD sensor is sealed by 3 protective plugs. Remove these plugs from the sensor before launching. Same for optode sensor, remove black plastic protection (located on top of sensor)

CTD Sensor

Protective plugs

(1 red and 2 white plugs)

Optode Sensor
(option)

Remove the magnet located near the top of the float (Figure 2 – General view of ARVOR-I float). Retain the magnet for future use in case the float is recovered.

ARVOR-I is now ready for launch.

To confirm that the magnet has been removed and that the float is ready for launch, 5 seconds after magnet removal, ARVOR starts 5 valves actions and 5 hydraulic pump activations followed by seabird pump activation. If you have water in the CTD, this water go out by the holes where were the protective plugs. Then float wait 50 sec (delay for user to connect by Bluetooth if needed) before performing an auto-test. If Auto-test is OK (up to several minutes), float will **activate buzzer for 30 minutes period**. This signal is the required condition for float deployment.

NOTE: Once the magnet has been removed, the ARVOR-I float performs an initial test (if armed mode is ON only). Ensure that the CTD pump starts as explained above before placing the float in the water.

Auto-test delay buzzer activation(for 30 minutes)can take several minutes.

If you do not hear the buzzer activation after a few minutes, and you do not see the water level change in conductivity cell, replace the magnet, connect the PC, and conduct the tests described in **section 2.5 page 11.** If these tests fail, contact **nke** technical support.

2.4.3 Deployment checklist

Test	Description	Expected Result	Result
Check before deployment			
1	Visual inspection	No scratch, good general state	☐ **OK**
2	Magnet Position	Magnet placed on ON/OFF position	☐ **OK**
3	Remove CTD(O) plugs (1 red & 2 white plugs)	Plugs removed (see section 2.4.2 page 8)	☐ **OK**
4	Distilled Water in conductivity cell	Introduce distilled water in conductivity cell (enable CTD pump check on test 8 & 9)	☐ **OK**
Check during deployment (Float must be on VERTICAL position)			
5 T0	Magnet removal	Magnet removed from ON/OFF position	☐ **OK**
6 T0+ [5-15s]	5 slow Ev activations	5 Ev activations heard (5-15 sec after magnet removal)	☐ **OK**
7	5 pump activations	5 pump activations heard	☐ **OK**
8	CTD pump	Water level change in CTD water circuit	☐ **OK**
	One Minute Delay before mission begins	During 50 sec, user can connect to float with Bluetooth to enter in dialog mode. After this delay, floats begins mission (no more dialog possible with float, until new reset)	☐ **OK**
9 T0+ 100s	Full Auto-Test	Full auto-test (int. vacuum, batteries, sensors test, short pump & Ev activation, GPS acquisition, and Iridium technical messages transmission (type 0 & 4) **Requires satellite visibility**	☐ **OK**
10 T0+ 140s	**Buzzer activation**	**Buzzer activates for 30 minutes** **DEPLOYMENT AUTHORIZATION**	☐ **OK**
11	Delay before mission	Wait for “Delay before mission” Minutes (“MC6”)	☐ **OK**
12	Satellite Transmission	IRIDIUM transmission (With refreshed GPS position)	☐ **OK**
Deployment			
13	Deployment	Deployment system in place	☐ **OK**
14	Float drift	Float drift at surface. **(Max delay for deployment : 1 hour after magnet removal)**	☐ **OK**

Table 1 - Deployment checklist

If **step 10** is not reached, place magnet on ON/OFF position and try again from beginning (Step 5)

Do not DEPLOY after 3 unsuccessfull tries !

2.4.4 Launch the float

NOTE: Keep the float in its protective packaging for as long as possible to guard against any nicks and scratches that could occur during handling. Handle the float carefully, using soft, non-abrasive materials only. Do not lay the float on the deployment vessel's unprotected deck. Use cardboard or cloth to protect it.

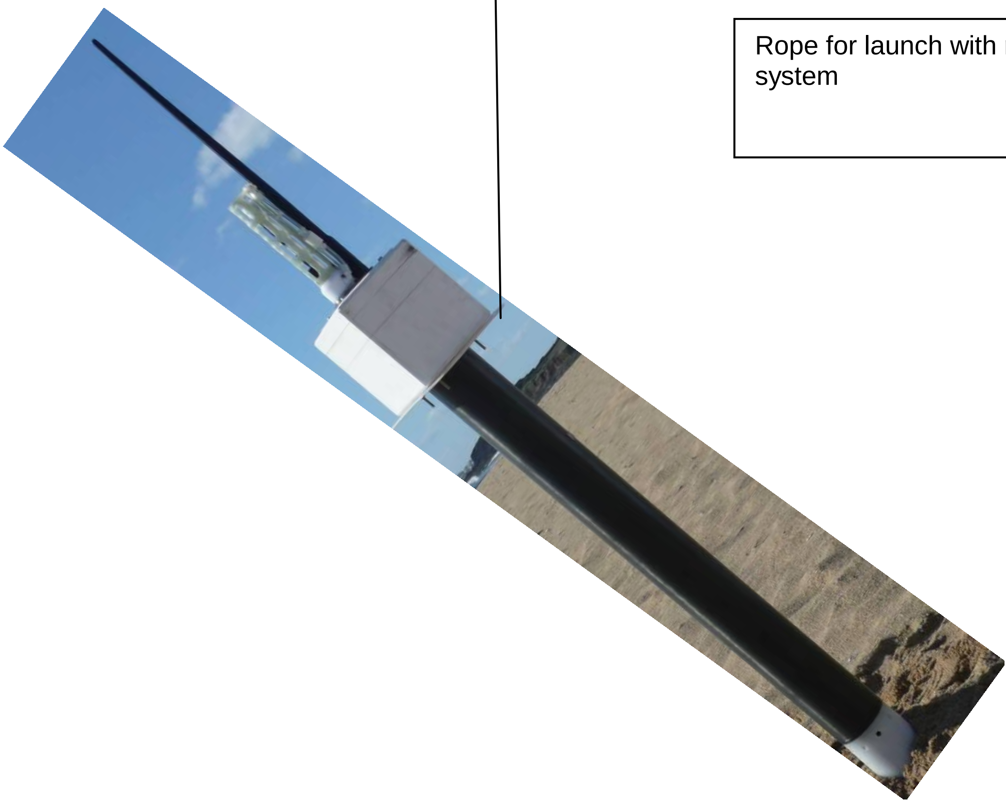
2.4.4.1 By hand

ARVOR-I can be launched by hand from the deck from a height of 2 meters maximum.

2.4.4.2 Using a rope

The damping disk is already fastened on the tube (under the buoyancy foam).
It is possible to use the holes in the damping disk in order to handle and secure the float during deployment.

Put the rope in the hole according to the following photo :



Rope for launch with release system

After the launch, you may decide to wait alongside the float until it starts its descent, but this can take up to 3 hours depending on the float's buoyancy when it is placed in water.

2.5 Automatic Launching (optional mode)

2.5.1 Description

This automatic launching is a mode that allows the float to start its mission on pressure detection. To do so, the float will be prepared, armed and will switch into pressure scanning for the next 90 days. Beyond this delay, he will begin mission.

Once the float is deployed, he dives because of his specific ballasting and as the pressure detection is confirmed, the float rises to surface to transmit its initial Iridium session and then starts profiling.

IMPORTANT : A specific mode that have to be ask at the order.

2.5.2 Laboratory preparation

2.5.2.1 Test the float and arm the mission

Before you take ARVOR-I on deck for deployment, we recommend that you repeat all of the tests described in **section 2.5.8** **"Display Sensor Data"**. This will ensure that the float is functioning and configured correctly and maximize the probability of success of your experiment.

IMPORTANT: Before launching the float, you must arm the mission by issuing the !AR command:

!AR

ARVOR-I will execute auto-test (see section 2.6.8 page 20 for description) and respond :

<AR ON>

Put the magnet on the float (ON/OFF position).

NOTE: Once the mission is armed, the next time you will attempt to communicate with the float upon magnet removal, you need to establish Bluetooth connection (see section 2.6.2 page 15) and press "ENTER" within 50 seconds after 5 pump activations in order to get the prompt].

2.5.2.2 *Float check in laboratory*

IMPORTANT : Check this list below to confirm that the float is in waiting of depoyment.

Test	Description	Expected Result	Result
1	Visual inspection	No scratch, good general state	☐ **OK**
2	Magnet Position	Magnet placed on ON/OFF position	☐ **OK**
3	Distilled Water in conductivity cell	Introduce distilled water in conductivity cell (enable CTD pump check on test 7 & 8)	☐ **OK**
(Float must be on VERTICAL position			
4 T0	Magnet removal	Magnet removed from ON/OFF position	☐ **OK**
5 T0+ [5-15s]	5 slow Ev activations	5 Ev activations heard (5-15 sec after magnet removal)	☐ **OK**
6	5 pump activations	5 pump activations heard	☐ **OK**
7	CTD pump	Water level change in CTD water circuit	☐ **OK**
8 T0+ 100s	Full Auto-Test	Full auto-test (batteries, sensors test, short pump & Ev activation, GPS acquisition, and Iridium technical messages transmission (type 0 & 4) **Requires satellite visibility**	☐ **OK**
9 T0+ 140s	**Buzzer activation**	**Buzzer activates for 30 minutes** **DEPLOYMENT AUTHORIZATION**	☐ **OK**
10	Float ready	The float is now ready to be deployed **(within 90 days maximum)**	

Table 2 – Float check in laboratory

If **step 9** is not reached, place magnet on ON/OFF position and try again from beginning (Step 4)

Do not DEPLOY after 3 unsuccessfull tries !

2.5.3 Deployment day

2.5.3.1 Remove protective plugs and magnet

The pump system of the CTD sensor is sealed by 3 protective plugs. Remove these plugs from the sensor before launching. Same for optode sensor, remove black plastic protection (located on top of sensor)

CTD Sensor

Protective plugs

(1 red and 2 white plugs)

Optode Sensor (option)

2.5.3.2 Deployment checklist

Test	Description	Expected Result	Result
Check before deployment			
1	Visual inspection	No scratch, good general state	☐ **OK**
3	Remove CTD(O) plugs (1 red & 2 white plugs)	Plugs removed (see 2.5.3.1 page 13)	☐ **OK**
Deployment			
13	Deployment	Deployment system in place	☐ **OK**
14	Float at sea	Float dives immediately	☐ **OK**

Table 3 - Deployment checklist

2.5.4 Launch the float

***NOTE:** Keep the float in its protective packaging for as long as possible to guard against any nicks and scratches that could occur during handling. Handle the float carefully, using soft, non-abrasive materials only. Do not lay the float on the deployment vessel's unprotected deck. Use cardboard or cloth to protect it.*

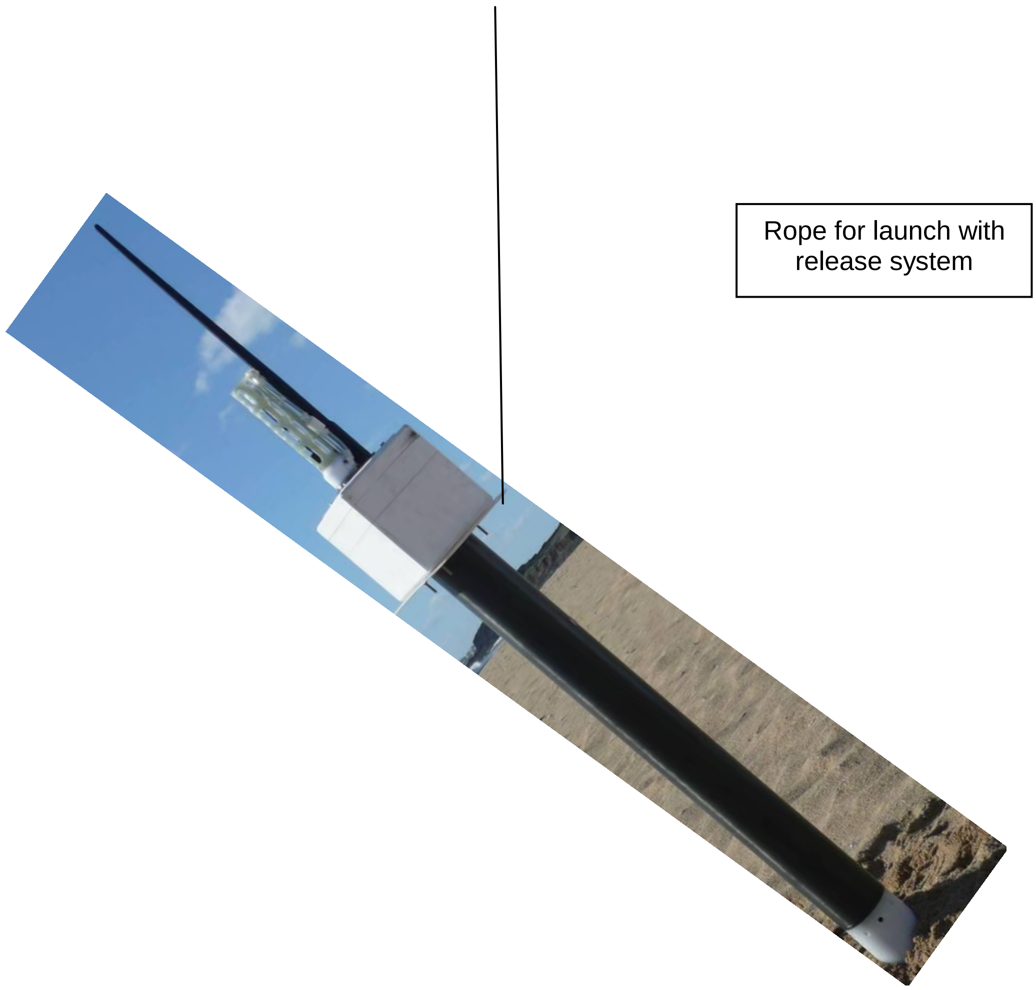
2.5.4.1 By hand

ARVOR-I can be launched by hand from the deck from a height of 2 meters maximum.

2.5.4.2 Using a rope

The damping disk is already fastened on the tube (under the buoyancy foam).
It is possible to use the holes in the damping disk in order to handle and secure the float during deployment.

Put the rope in the hole according to the following photo :



After the launch, you may check that the float dives immediately.

2.6 Checks prior to deployment

This chapter deals with test to perform in laboratory, before float is put in its wooden box. These tests can be performed on ship only by experienced users.

2.6.1 Necessary Equipment

The equipment required to check that ARVOR-I is functioning correctly and to prepare it for the mission are:

(1) A PC.
The most convenient way of communicating with ARVOR-I is with a PC in terminal emulation mode. Among other advantages, this allows storage of configuration parameters and commands. You can use any standard desktop or laptop computer. The PC must be equipped with a serial port (usually called COM1 or COM2).

(2) VT52 or VT100 terminal emulation software.
The Hyper Terminal emulation software can be used.

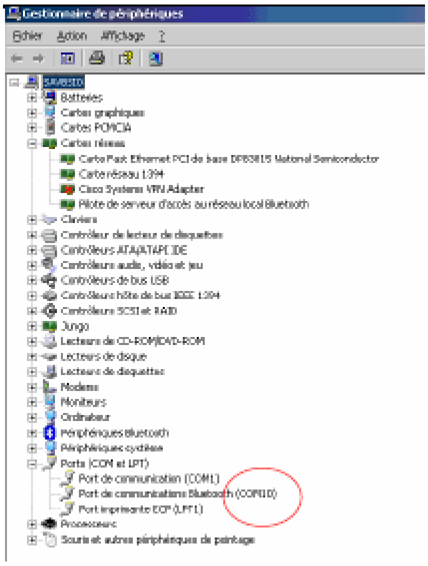
(3) A Bluetooth Dongle with drivers installed on the PC (BELKIN class 2 model is recommended).

2.6.2 Connecting the PC

Make sure you check the following points before attempting a connection:

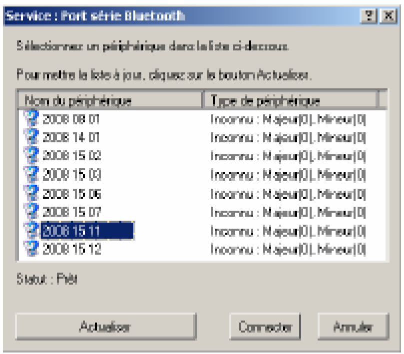
- ✓ Bluetooth key connected to the PC with the drivers installed
- ✓ Magnet present at the Bluetooth’s power supply ILS, see Figure 2 – General view of ARVOR-I float

- ✓ Start Hyperterminal after checking on which COM port the Bluetooth key is installed by going to: Control Panel->System-> Click on Hardware tab->Device Manager as shown in the figure below:



- ✓ On the PC, run the following commands as shown in the figure below
- ✓ Right click on the Bluetooth logo in the bottom right corner of the Desktop
- ✓ Select Quick Connect, Bluetooth Serial Port, then click on other devices

A window appears as shown in the figure below:



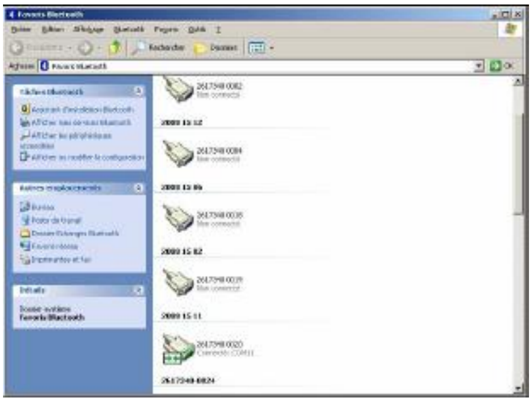
- ✓ Click on Refresh
- ✓ Check that the Bluetooth number is present on the traceability label, see Figure 2 – General view of ARVOR-I float

- ✓ There are two ways of establishing the connection:
- ✓ Either select the number shown and press Connect
- ✓ Or come back to the previous step and instead of selecting “other devices”, select the number shown
- ✓ When the connection is made, a dialog box appears as shown in the figure above:

Double click on it and a window appears as shown below:

- ✓ Enter the security code “0000”
- ✓ You can now check the connection by double clicking on the Bluetooth logo in bottom right corner of the Desktop

- ✓ The “Bluetooth favourites” window appears:



Use your PC's terminal emulation software to configure the selected serial port for:

- 9,600 baud
- 8 data bits
- 1 stop bit
- Parity: none
- Full duplex
- No flow control

2.6.3 Example of Bluetooth dongle tested by NKE

USB Bluetooth™ – 100 meters
Part# F8T012fr
Made By belkin

2.6.4 How to send commands

You must communicate with ARVOR-I to verify or change its configuration parameters, to read data from the float, or to test the float's functions. You perform these verifications/changes by sending commands, and by observing the float's response to those commands. Compose commands by typing characters on the keyboard of your PC, and send them to ARVOR-I by pressing the Enter key.
In the following descriptions of commands we will use the general syntax:

- Keystrokes entered by the user are written in **bold**.
- Replies received from the float are in normal font.
- Commands entered by the user end with the Enter key.

Complete description and list of user command can be read using the command **?HE** and is also given in Section User commands (terminal commands to float) on page 42

The software version can be viewed using the **?VL** command

ARVOR-I will respond:

<VL 5900Y0x (where Y indicates major software revision and x indicates minor software revision)

<VC IRIDIUM>

<HY ARVOR>

<Firmware make ID : 1>

The float’s serial number can be viewed using the **?NS** command

ARVOR-I will respond:

<NS 00001> (identification 1)

2.6.5 How to read and change parameter values

Read the values of “mission commands” by sending the MC command. Do this by typing the characters **?MC** in response to ARVOR's ‘]’ prompt character then confirm the command by pressing the Enter key. It should look like this:

?MC

ARVOR will respond:

<MC0 300 Total cycle nb >
<MC1 300 Nb cycles with Cycle period 1 >
<MC2 240 Cycle period 1 (Hours) >
<MC3 240 Cycle period 2 (Hours) >
<MC4 2 Reference day >
<MC5 6 Hour at surface >
<MC6 0 Delay before mission (Minutes) >
<MC7 1 CTD sampling mode (1=Std, 2=Eco, 3=Mixed, 4=Spot sampling) >
<MC8 0 Descent CTD sampling period (Seconds) >
<MC9 12 Drift CTD sampling period (Hours) >
<MC10 10 Ascent CTD sampling period (Seconds) >
<MC11 1000 Drift pressure 1 (dBars) >
<MC12 2000 Profile pressure 1 (dBars) >
<MC13 1000 Drift pressure 2 (dBars) >
<MC14 2000 Profile pressure 2 (dBars) >
<MC15 1 Alternate cycle number (1=not used, x=1/x alternated profile) >
<MC16 2000 Alternate profile pressure (dBars) >
<MC17 10 Threshold Zone 1/2 (dBars) >
<MC18 200 Threshold Zone 2/3 (dBars) >
<MC19 1 Slice thickness in zone 1-Surface (dBars) >
<MC20 10 Slice thickness in zone 2-Intermediate (dBars) >
<MC21 25 Slice thickness in zone 3-Deep (dBars) >
<MC22 60 Iridium End of Life Period (Minutes) >
<MC23 0 Time between 1st&2nd Iridium session(0=no 2nd session, in min) >
<MC24 0 Grounding mode (0=Shift, 1=Stay grounded) >
<MC25 100 Grounding shift (dBars) >

<MC26 10 Wait at surface if grounding (Minutes) >
<MC27 0 Optode type (0=no optode, 1=4330, 2=3830, 3=ext. sensor) >
<MC28 5 CTD CutOff pressure (dBars) >
<MC29 0 In air acq: Periodicity of in air measurement (0=no acq, 1=acq. on each cycle, x=acq. on 1/x cycle)>
<MC30 30 In air acq.: Sampling period (Seconds) >
<MC31 5 In air acq.: Acquisition duration (Minutes) >

As you can see, the responses are of the form:

- MC parameter number, value.

You can also read the values of the parameters individually using the command : **?MC X**

where **X** identifies the parameter. Each parameter is identified by a parameter number corresponding to a parameter name. They are summarised for reference in **section 5.1 & 5.2 page 37 ***

Command no.	Name	Default Value	Units	Min Value (*)	Max value (*)
MC0	Total number of cycles	300	Whole number	0 (**)	999
MC1	Number of cycles with cycle period 1	300		0	999
MC2	Cycle period 1	240	Hours	1	480
MC3	Cycle period 2	240	Hours	1	480
MC4	Reference day	2	Number of days	0	40
MC5	Expected time at the surface	6	Hours	0	23
MC6	Delay before mission	0	Minutes	0	1440
MC7	CTD sensor acquisition mode	1		1	4
MC8	Descent sampling period	0	Seconds	0 (***)	600
MC9	Drift sampling period	12	Hours	0	240
MC10	Ascent sampling period	10	Seconds	8	600
MC11	Drift depth for "MC1" first cycles	1000	dBar	0	2020
MC12	Profile depth for "MC1" first cycles	2000	dBar	0	2020
MC13	Drift depth after "MC1" cycles are done	1000	dBar	0	2020
MC14	Profile depth after "MC1" cycles are done	2000	dBar	0	2020
MC15	Alternated profile period	1		1	20
MC16	Profile pressure of alternated profile	2000	dBar	0	2020
MC17	Threshold surface/Intermediate Pressure	10	dBar	0	2000
MC18	Threshold Intermediate /Bottom Pressure	200	dBar	0	2000
MC19	Thickness of the surface slices	1	dBar	1	1000
MC20	Thickness of the intermediate slices	10	dBar	1	1000
MC21	Thickness of the bottom slices	25	dBar	1	1000
MC22	Iridium End of Life transmission period	60	Minutes	2	7200
MC23	2^{nd} iridium session wait period	0	Minutes	0	360
MC24	Grounding mode (0: shift, 1: stay grounded)	0		0	1
MC25	Grounding switch pressure	50	dBar	10	200
MC26	Delay after grounding at surface	10	Minutes	0	2400
MC27	Optode type (0: none, 1: 4330, 2: 3830)	0		0	2
MC28	CTD sensor Cut-Off pressure (Pump stop)	5	dBar	2	60
MC29	"In Air" acquisition cycle periodicity	0		0	250
MC30	"In Air" acquisition sampling period	30	Seconds	10	300
MC31	"In Air" acquisition total duration	5	Minutes	0	3600

Table 4 - Mission parameters

(*) : User should not program value over these limits. Risk for float integrity could be created if done
(**) : "0" for descent sampling rate means no acquisition. If acquisition is requested, minimum value is 8 seconds

For example, to verify the value of the ascent sampling period, send the command:

? MC 10

ARVOR will respond:

<MC10   10>

where 10 is the sampling period in ascent.

The commands for **changing** the values of the mission parameters are of the form :

!MC X Y

where X identifies the parameter and Y provides its new value.

For example, to change the number of cycles with “period 1” to 150, send the command :

!MC 1 150

ARVOR will respond:

<MC1   150>

NOTE: ARVOR will always respond by confirming the present value of the parameter. This is true even if your attempt to change the parameter's value has been unsuccessful, so you should observe carefully how ARVOR responds to your commands.

2.6.6 How to check and change the time

Connect the PC to the float using the BT connection (see **section 2.6.2 page 15**). Ask ARVOR-I to display the time stored in its internal clock by sending the command:

? TI

(Do this by typing the characters **? TI** followed by the Enter key). ARVOR-I will respond:

01/03/14, 14h 41m 00s

]

The date and time are in the format DD/MM/YY, HHh MMm SSs

You can set the time on the float's internal clock by sending the command:

!TI DD MM YY hh mm ss

For example, if you send the command:

!TI 01 03 14 14 30 00

ARVOR-I will respond:

01/03/14, 14h 30m 00s

]

2.6.7 Configuration check

The float has been programmed at the factory. The objective of this portion of the acceptance test is to verify the float's configuration parameters.

Connect the PC to the float (see **section 2.6.2 page 15**). Send the PM command, as explained in **section 2.6.5. page 18**, to verify that ARVOR-I's parameters have been set correctly.

All command list is given in Section “USER COMMANDS” page 37

2.6.8 Functional tests

Connect the PC to the float (see **section 2.6.2**).

NOTE: The hydraulic components will function correctly only if the float is in a vertical position with the antenna up.

Orient the float vertically, and support it to prevent it from falling over during the performance of the functional tests.

ARVOR-I has several commands that allow you to test its various functions.

2.6.8.1 Auto-test

Before sending float auto-test, place the float on vertical position.

Float can realize 2 kind of auto-tests. The “standard one” and the “full auto-test”. These auto-test are used by float to check all internal components.

Standard auto-test can be done by sending command :

!C 0

Float will respond :

CPU : OK

INT. VACUUM: OK (600mbars)

BATTERY : OK (10.7V)

HYDR. PUMP : OK (Voltage dropdown:0.4V)

HYDR. VALVE: OK (Voltage dropdown:0.6V)

CTD MODE : OK

FP MODE : OK

OPTODE : (No Optode, type = 0)

IRIDIUM/GPS: OK

FLASH : OK (calc:5CD4 read:5CD4) (Checksum values depends on firmware version)

During auto-test, float will test “internal vacuum”, CTD sensor (CTD mode and pressure request), Dialog with Iridium modem, parameters integrity and firmware integrity (checksum).

Full auto-test is identical to standard auto-test, with addition of GPS position acquisition with good fix, SBD message transmission and buzzer activation once test is finished and successful. So float needs satellite visibility (both GPS and Iridium constellation).

Full auto-test can be done by sending command **!C 1**

2.6.8.2 Display of technological parameters

This command is used to display :

- Internal vacuum (V)
  This vacuum is drawn on the float as one of the final steps of assembly. It should be between 500 and 700 mbar absolute. 600 mbar (@20°C) is recommended.
- Battery voltage (B)
  Normal values for a new battery are 10.8 volts (see test sheets for limits).
  Send the command :

?VB
ARVOR-I will respond:

<B:109 V:605 (A=2.000 B=-200.000)> meaning 10.9V for battery voltage and 605 mBar as internal vacuum

A & B coefficients are specific to float and vary from one to another.

A & B coefficients value can be checked on document FIT provided with float

2.6.8.3 Display sensor data

2.6.8.3.1 CTD Data

This command is used to display:

- External pressure (P)
- Temperature (T)
- Salinity (S)

Send the command:
?S
ARVOR-I will respond:
<S: 10cBars 24561mdc 12mPSU>
As this sensor is in open air, only the temperature data should be regarded as accurate.

2.6.8.3.2 Oxygen Data

This command is used to display dissolved oxygen data frame

Send the command:

?D

ARVOR will respond:

2.6.8.4 Test Hydraulic engine

Hydraulic engine is composed of high pressure pump and electro-valve. Pump transfers oil from internal tank to external bladder, to increase float's volume for ascending phase. Valve transfer oil from external bladder to internal one, for descending phase.

2.6.8.4.1 Test hydraulic pump

To activate the pump for one second, send the command :
!P 100
Listen for the pump running for one second (unit: centiseconds).

2.6.8.4.2 Test hydraulic valve

To activate the valve for one second, send the command:
!E 100
Listen for the actuation of the valve (unit: centiseconds).

NOTE: ARVOR is delivered with hydraulic device ready for deployment.

If during tests, hydraulic pump or valve is activated for long cumulated duration, this could cause trouble at deployment:

- ***A long valve activation, will empty external bladder. If volume of external bladder is too small, float will not have enough buoyancy to stay at surface at deployment for Initial Iridium session.***
- ***On the other side, A long pump activation once external bladder is full is not recommended at all, (could cause pump unpriming).***

2.6.8.5 Test GPS subsystem

To test the GPS, send the command:
?GP
Float will acquire GPS position and update float's internal clock with GPS date and hour.

Float will respond :
MESSAGE > Old Time:13aa12mm 09jj 14hh42mn31ss New Time:13aa 12mm 09jj 14hh42mn32ss

Float answer can take a few minutes depending on GPS satellite visibility.

2.6.8.6 Test Iridium subsystem

To test the Iridium transmitter, place float outside with satellite visibility and send the command:

!SE

The float will reprogram time with GPS, then will send technical SBD message (packet type 0 & 4). Put the magnet back in place to stop the transmission.

This command will cause ARVOR-I to transmit one technical message. The format of which is described in **section 6 page 44**. Use your email address to check transmission was OK. The message content is not meaningful, this is a test of the transmission only.

2.6.8.7 Check armed mode

To check if armed mode is ON or OFF, send the command :

?AR

Float will respond :

<AR ON> if armed mode is ON or <AR OFF> if armed mode is OFF. Float will execute an auto-test in order to check that all sub-assemblies are ready for deployment.

Armed mode set "ON" (=1) means that float is ready for deployment. Armed mode set to OFF (=0)means that float enters in "user-dialog mode" each time float is powered ON.

Before deployment, armed mode must absolutely be set to ON !

If armed mode is ON, next time float is powered ON, after a delay of 50 seconds, float begin a new mission and it won't be possible to send command by Bluetooth to float anymore. During the 50s delay, user can enter in "dialog mode" by connecting on bluetooth and type on "ENTER" character until float send prompt character (**"]"**).

Armed mode is set in factory on request. This information (AR state) can also be verify by reading FIT file delivered with float.

You have now completed the functional tests. Ensure the magnet is in place on the ON/OFF position (see Figure 1 - Magnet positions).

Tip : To ensure that float is powered OFF, place magnet on ON/OFF before 5th slow valve activation. In that case, if click stopped before 5th activation, you are sure that magnet in on right position and float power is OFF.

NOTE : With armed mode to ON, a float that stay powered ON in "dialog mode" with user (for example after tests in laboratory) will automatically start mission in a delay of 48 hours after last exchange by bluetooth with user (=after 48 hours in stand-by mode).

3 GENERAL DESCRIPTION OF ARVOR-I FLOAT

3.1 ARVOR-I

The main developments of ARVOR-I compared to the PROVOR CTS-3 float are mainly:

- ✓ Embedded software,
- ✓ Electronics,
- ✓ Battery pack,
- ✓ Float casing frame,
- ✓ MMI link.

3.1.1 Electronics

A new CPU board has been developed to take into account the obsolescence of components of the CTS-3 profiler.

3.1.2 Embedded software

The CPU board is equipped with a new embedded software taking into account supplementary inputs and possibilities required by the ARVOR-I float.

3.2 Hull

The ARVOR-I float is encased in an aluminium cylinder measuring 11.3 cm in diameter and 100 cm in height. A surface finish prolongs life by impeding corrosion. The float is carefully designed to have a compressibility that is lower than that of seawater, essential for stable operation at ocean depths where pressures reach 200 atmospheres.

The influence of surface swell upon the instrument's heave is attenuated by a Buoyancy foam pad positioned around the upper part of the hull.

3.3 Magnet positions

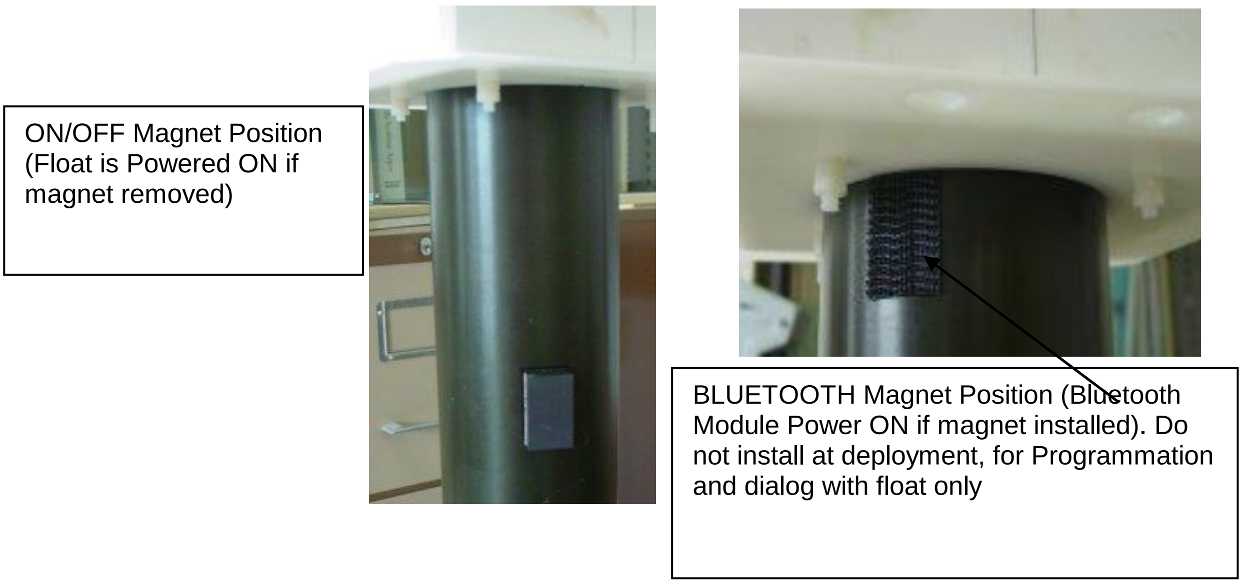


Figure 1 - Magnet positions

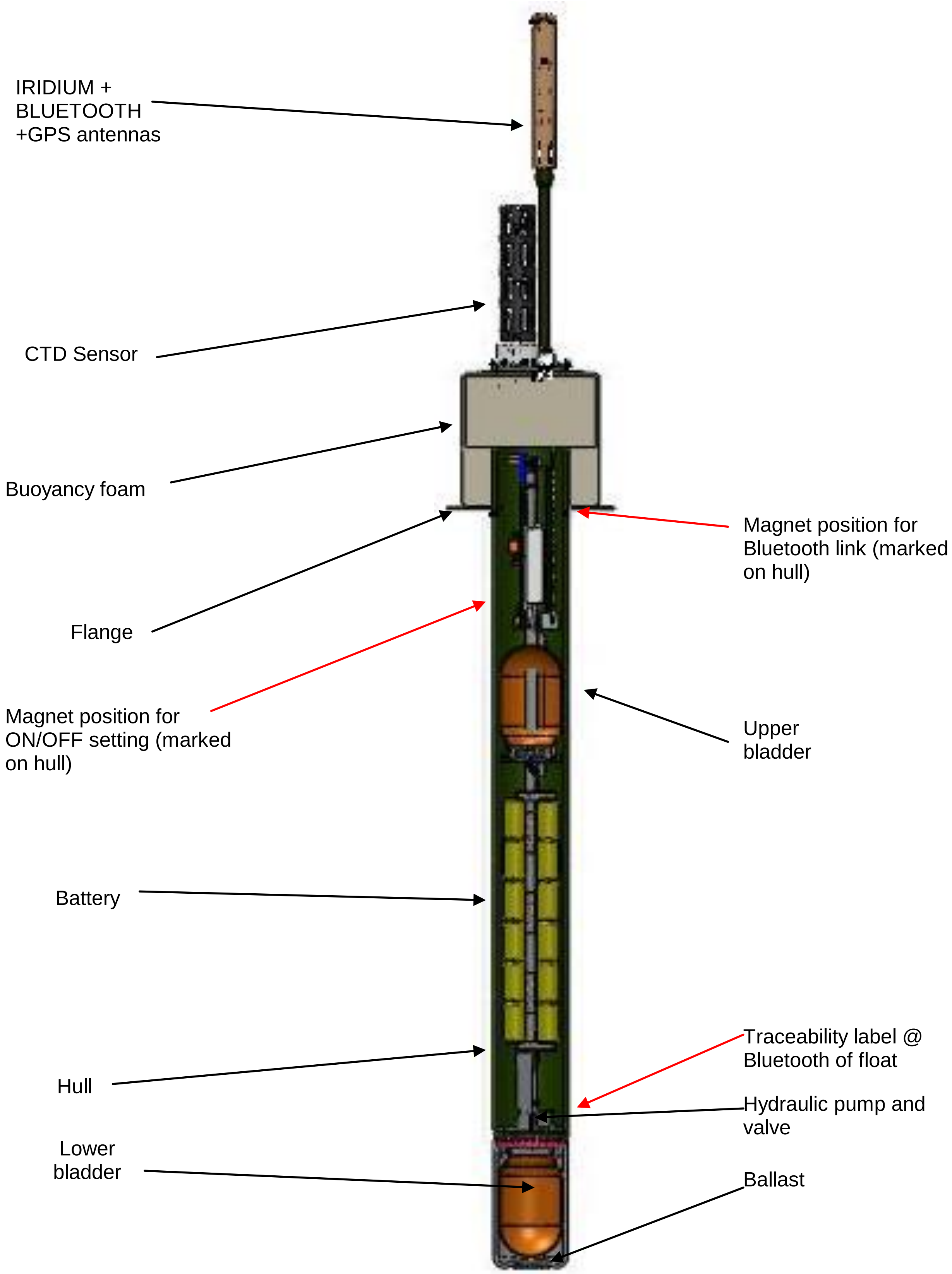


Figure 2 – General view of ARVOR-I float

3.4 Density control system

Descent and ascent depend upon buoyancy. ARVOR-I is balanced when its density is equal to that of the level of surrounding water. The float has a fixed mass. A precision hydraulic system is used to adjust its volume. This system inflates or deflates an external bladder by exchanging oil with an internal reservoir. This exchange is performed by a hydraulic system comprising a high-pressure pump and a solenoid valve.

The interested reader is referred to a more detailed description of the operation of ARVOR-I's density control system in **section 8 page 67.**

3.5 Sensors

ARVOR-I is equipped with precision instruments for measuring :

- pressure, temperature and salinity with the SEABIRD SBE41CP CTD sensor. Specifications of the sensor are provided in **section 7 page 66.**
- Dissolved Oxygen with the Oxygen Optode AANDERAA 3830 or 4330 sensor (Optional)

3.6 IRIDIUM/GPS MODEM

While the float is at the surface, the Iridium Modem sends stored data to the satellites of the Iridium system (see **sections 6. Page 44**). The transmitter has a unique IMEI ID. This ID identifies the individual float. The antenna is mounted on the top end of the ARVOR-I float and must be above the sea surface in order for transmissions to reach the satellites.

3.7 CPU board

This board contains a micro-controller (or CPU) that controls ARVOR-I. Its functions include maintenance of the calendar and internal clock, supervision of the depth cycling process, data processing and activation and control of the hydraulics.

This board allows communication with the outside world for the purpose of testing and programming (with Bluetooth link).

3.8 Battery

A battery of lithium thionyl chloride cells supplies the energy required to operate ARVOR-I.

3.9 MMI link

The User link is made via Bluetooth (radiofrequency link).

3.10 Firmware evolution in 2015 (firmware 5900A00, 5900A01 & 5900A02)

ARVOR-I firmware has been modified in 2015 with several objectives. Main objectives were :

- Better resistance to deployment conditions (auto-test improvement, ...)
- Deployment procedure simplification (with use of Buzzer)
- Possibility to program 2 Mission schemes (2 cycle period, with associated Parking and Profile Depth) (see figure 8 on page 37 for more details about cycle possibility)
- Increase technical return from float (creation of a 2nd technical message)
- Sampling capability increasing (from 308 CTD points per cycle to 2015 CTD points per cycle)
- User interface simplification*

3.11 Firmware evolution in 2016 (firmware 5900A03 & higher)

ARVOR-I firmware has been modified in 2016 with several objectives. Main objectives were :

- “Near Surface” and “In Air” measurement phases were added at the end of ascent phase. This is specifically useful for float equipped with optional dissolved oxygen sensor (optode), for saturation control in order to compensate potential sensor drift
- Ice detection possibility (option), based on Ice Sensing Algorithm (ISA for Antarctic area)
- Because of ice detection capability, SBD messages are now stored in float’s memory, for transmission on a following cycle, as soon as satellite transmission becomes possible
- Technical packet (type =0) modification with addition of IRIDIUM timeout information, and creation of progammation packet n°2 (ice commands)

4 THE LIFE OF AN ARVOR-I FLOAT

The life of an ARVOR-I float is divided into 4 phases: Storage/Transport, Deployment, Mission, & Life Expiry.

(1) Storage/Transport
During this phase, the float, packed in its transport case, awaits deployment. The electronic components are dormant, and float's buoyancy control functions are completely shut down. This is the appropriate status for both transport and storage.

(2) Deployment
The float is removed from its protective packaging, configured, tested and launched at sea.

(3) Mission
The mission begins with the launching of the float. During the mission, ARVOR-I conducts a pre-programmed number of cycles of descent, submerged drift, ascent and data transmission. During these cycles it collects CTD data, computes data, and transmits it to the IRIDIUM satellites system.

(4) Life Expiry
Life Expiry begins automatically upon completion of the pre-programmed number of cycles. During Life Expiry, the float, drifting on the sea surface, periodically transmits messages until the battery is depleted. Reception of these messages makes it possible to locate the float, to follow its movements and, if desired, to recover it. ARVOR-I floats are designed to be expendable, so recovery is not part of its normal life cycle, but is possible with Iridium telecommand.

If the battery is depleted before completion of the pre-programmed number of cycles, ARVOR-I will probably remain submerged and cannot be located nor recovered.

4.1 The mission - overview

We call "mission" the period between the moment when the float is launched at the experiment zone and the moment when the data transmission relating to the final depth cycle is completed.

During the mission, ARVOR-I conducts ascent and descent profiles, separated by periods of IRIDIUM transmitting and drifting at a predetermined depth. ARVOR-I can collect data during the descent, submerged drift, or ascent portions of the cycle, and transmits the collected data during the surface drift period at the end of each cycle. One cycle is shown in the figure below.

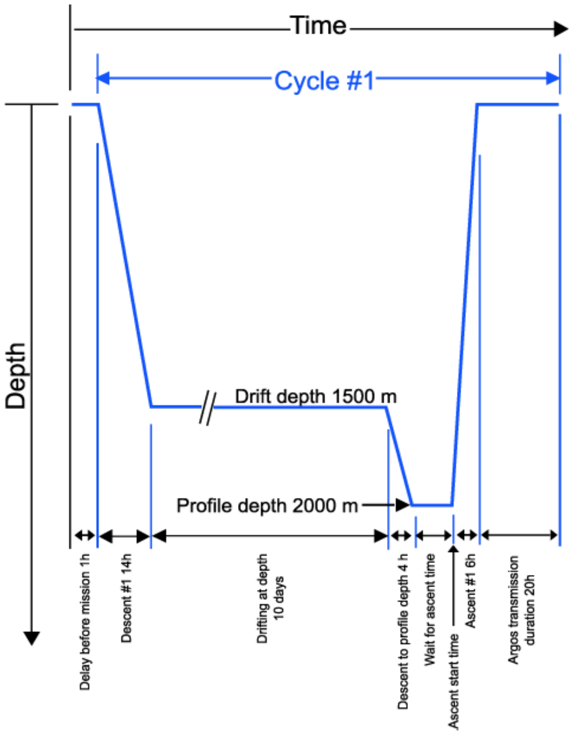


Figure 3 Schematic representation of a ARVOR-I's depth-cycle during the mission

(1) Delay before mission (deployment only)
To prevent ARVOR-I from trying to sink before it is in the water, the float waits for this time before starting its descent. This happens only before the first cycle; it is not repeated at each cycle. Duration of delay is given by parameter MC6.

(2) IRIDIUM/GPS preliminary transmissions
To test IRIDIUM transmitter, before the first descent phase, float performs IRIDIUM transmission by sending a technical message. A GPS position is acquired and transmitted in technical message. First packet are transmitted during float autotest, then at beginning of mission, a 2nd message is sent.

(3) "Pressure sensor offset" reset
Resetoffset command is send to SBE41-CP sensor -> Sample pressure for 1 minute. Store measured pressure as new pressure offset. Maximum allowed offset is 2 percent of full scale. New offset will be transmitted by float at the end of the cycle in technical message (#43 from packet type 0)

(4) Buoyancy reduction
Float is deployed with full external bladder to get a maximal buoyancy. To reach a neutral buoyancy position before descending, float needs to transfer oil inside float. For the 2 first cycles this phase can take up to one hour and a half (by opening electro-valve several times with one minute for pressure monitoring between activations). For the following cycles, float memorizes necessary global electro-valve opening time (precedent cycle) and reduces this global duration by reducing the time between valve activations to 5 seconds instead of 1 minute.

(5) Descent
The float descends at an average speed of 2.7 cm/sec. During descent, which typically lasts a few hours, ARVOR-I can detect possible grounding on a high portion of the seabed and can move away from such places (see **section 4.5. page 30** for more details on grounding). ARVOR-I can collect CTD measurements during descent or ascent.
In order to respect the requirement of the ARGO program, the first cycle of the mission always collects CTD measurements during the descent at the sampling period of 10 seconds (even if "MC8" is set to 0).

(6) Drifting at parking depth
During the drift period, ARVOR-I drifts underwater at a user-selected drift depth, typically 1,000m to 2,000m below the sea surface. The drift period is user-selectable and can last from a few days to several weeks, but is typically 10 days. The float automatically adjusts its buoyancy if it drifts from the selected depth by more than 50 dBar over a 60-minute period. ARVOR-I can collect CTD measurements at user-selected intervals ("MC9") during this drift period if the user selects this option.

(7) Descent to profile depth
The user may select a starting depth for the ascent profile that is deeper than the drift depth. If this is the case, ARVOR-I must first descend to the profile depth before beginning the ascent profile.
ARVOR-I can detect a possible grounding during this descent and take corrective action (as described in **section 4.5. page 30)**

(8) Wait for ascent time
The user can program several floats to conduct profiles simultaneously. This makes it possible to use several ARVOR-I floats in a network of synoptic measurements, even though the instruments are not deployed at the same time. If this is the case, it may be necessary for ARVOR-I to standby at the profile starting depth while awaiting the scheduled ascent time.

(9) Ascent
Ascent lasts a few hours, during which time ARVOR-I ascends to the sea surface at an average speed of 10cm/sec. ARVOR-I can collect CTD measurements during descent or ascent. In case of ice detection, ascent is aborted, float stores SBD messages in memory and then shifts to following cycle without going through classical phase of "In Air" measurement and transmission. Ice detection is made during this phase according to ice parameters (see section 5.2). In case of ice detection, ascent is ended, float creates and stores SBD packets for past profile, then switches to following cycle

(10) "Near Surface" and "In Air" Measurement
Floats realizes specific acquisition for CTD and Dissolved Oxygen (option) near surface and also after float reaches maximum buoyancy. This acquisition is done or not depending on MC29, 30 & 31 values.

(11) Transmission
At the end of each cycle, the float finds sufficient buoyancy to ensure Iridium transmission quality and GPS positioning. ARVOR-I remains at the sea surface transmitting the data collected during the preceding descent-drift-ascent portion of the cycle.

4.2 Float's AUTO-TEST

Before starting mission, float will execute an auto-test. In case of success, float will indicate that deployment can be done with use of buzzer (beep during 30 min). Once buzzer has started, float can be deployed. Duration between magnet removal and buzzer sound can change depending on duration for GPS acquisition & Iridium transmission.

4.3 Buoyancy reduction phase

At beginning of cycle, while the float is still at the sea surface ARVOR-I measures and records its pressure sensor offset. This offset is used to correct all pressure measurements. The offset is transmitted in a technical message (see **section 6. Page 44** for a description of technical messages format).

Then, float will activate hydraulic valve to "reduce the buoyancy" of the float up to pressure target given by TC8, before entering in "Descent phase". During buoyancy reduction phase, float activates valve with action duration of several seconds (given by TC0 parameter) to transfer oil from external ballast to internal tank. Between each action, float will measure pressure from CTD sensor. As soon as pressure is greater than TC8 dBar (typ. 7 dBar), float change phase from "buoyancy reduction" to "descent". During buoyancy reduction phase, float do not collect CTD(O) measurement, meaning that descent profile do not include CTD(O) data from surface up TC8 dBar. This phase takes approx 1 hour for cycle 1 and 2 because of delay of minute between each valve action. For following cycles, float reduces delay between valve action to required delay for pressure measurement (less than 5 sec).

4.4 Descent to parking depth

Descent takes the float from the sea surface to the drift depth. Initially, in order to avoid possible collisions with ships, ARVOR-I's objective is to lose buoyancy in the shortest possible time. It does this by opening the solenoid valve for a time period that is initially long, but decreases as the float approaches its target depth.

If the user chooses, ARVOR-I collects CTD measurements during descent and/or during ascent. The time interval between CTD measurements is user-programmable. During descent, float reaches target pressure in a range of typ. +/- 30 dBar (Given by TC5 parameter)

4.5 Grounding

ARVOR-I monitors itself for possible grounding on the seabed. During descent to drift depth (Parking depth only), if the pressure remains unchanged for too long, ARVOR-I enters a correction mode. The user selects one of two available modes during Mission programming before launch (Mission command "MC24") :

- Grounding Mode(MC24) = 0: The pre-programmed drift depth is disregarded. The pressure at the time of grounding minus an offset (100 dBar typical, see MC25 value) is taken as the new value for the drift pressure. The float adjusts its buoyancy to reach this new parking drift depth. The drift depth reverts to its programmed value for subsequent cycles.
  If the grounded pressure is lower than a programmed threshold (200 dBar), the float remains on the seabed until the next programmed ascent time. This mechanism enables float to continue drift in order to potentially find deeper pressure as it need to descend to Profile pressure
- Grounding Mode(MC24) = 1: the float remains where it is until the next scheduled ascent time. The pressure measured at grounding becomes the profile start pressure for the cycle in progress. The profile start pressure reverts to its programmed value for subsequent cycles.

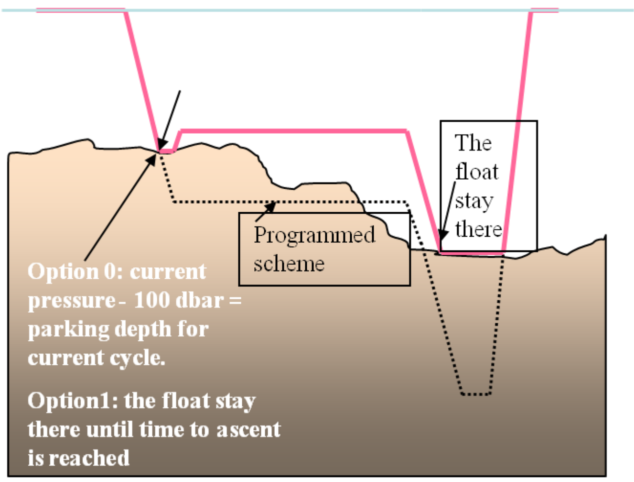


Figure 4 - Schematic representation of a ARVOR-I's behavior in case of grounding

4.6 Submerged drift

While ARVOR-I is drifting at drift depth, it checks the external pressure every 30 minutes to determine whether there is need either for depth adjustment or for an emergency ascent.

If the measured pressure differs from the drift depth pressure by more than a specified tolerance (typ. 50 dBar), and this difference is maintained, ARVOR-I adjusts its buoyancy to return to the drift depth.

If the pressure increases by an amount that exceeds a factory-set danger threshold, ARVOR-I immediately ascends to the sea surface.

If the user chooses, ARVOR-I collects CTD measurements at user-selected intervals (every MC9 hours) during submerged drift.

4.7 Descent to profile depth

If the chosen ascent profile starting pressure (MC12,or resp. MC14) is higher than the drift pressure (MC11, or resp. MC13), the float must first descend to reach the profile starting pressure.

If grounding is detected while ARVOR-I is descending to the profile starting pressure, the present pressure is substituted for the profile starting pressure. This substitution is only for the cycle in progress; the profile starting pressure reverts to its pre-programmed value for subsequent cycles. During this phase, float do not acquire CTD data, and monitors only pressure to reach target pressure.

4.8 Ascent

Once the profile starting pressure has been reached, the float waits for the programmed time to begin the ascent. If this time is reached before the float has arrived at the profile starting pressure, the ascent starts immediately.

ARVOR-I ascends by repeated use of the pump. When the pressure change between two successive measurements is less than 10 dBar, the pump is activated for a pre-set time period. In this way, the pump performs minimum work at high pressure, which ensures minimum electrical energy consumption. The average speed of ascent is approximately 10cm/sec. For a 2,000m profile, the ascent would therefore last 6 hours.

When the pressure drops below 10 dBar (signifying completion of ascent), ARVOR-I waits 10 minutes and then activates the pump in order to empty the reservoir and achieve maximum buoyancy. If the user chooses, ARVOR-I collects CTD measurements during descent and/or ascent. CTD measurements begin at the profile start time and stop 10 minutes after the float rises above the 10 dBar isobar in its approach to the sea surface. The time interval between CTD measurements is user-programmable. For example, during a profile beginning at 2,000 m with a 10 sec sampling period, 2,200 CTD measurements (raw data) will be collected. These samples will be then “treated” before transmission” (see 6.14 CTD(O) data treatment details).

4.8.1 Ice detection (with firmware 5900A03 and higher)

At the end of ascent, if ice detection option is activated, float starts ice detection in order to stop ascent and avoid hit ice with risk to remain blocked under ice.

To detect ice, float uses 3 mechanisms :

- ISA method (Ice Sensing Algorithm), used for Antarctic area
- Satellite visibility
- Pressure evolution

If ice is detected, float stops ascent and aborts “In Air “ measurement and satellite transmission. In that case, SBD packets are created and stored into float internal memory to be transmitted next time float will really reach surface.

4.8.1.1 ISA detection

Between 2 thresholds (IC3 & IC4); float computes median temperature. If temperature is inferior to IC5 (default : -1.79°C), float decides ice detection as positive. From threshold IC6, float decreases speed from approx. 9 cm/sec to approx. 3.33 cm/sec (default values), to acquire necessary raw CTD data to compute median temperature.

4.8.1.2 Satellite visibility

A 2nd mechanism enables to detect ice, based on GPS end Iridium satellite visibility.

4.8.1.3 Pressure evolution

A 3rd mechanism is based on pressure evolution during ascent phase. If during IC12 minutes, despite pump actions, pressure evolution is inferior to minimum value, float decides ice detection as positive. We call blocking in ascent phase.

Once ice detection is positive, float activates valve to transfer oil (volume given by IC14 parameter), until pressure has increased of IC13 dBar. In the same time, float creates SBD packets for past cycle, and stores all packets in non-volatile memory. Float can store up to 2410 SBD packets (of all types). These packets will be transmitted during next transmission session. More ancient packets will be erased by new ones, in case, float remains for long time under water without emergence & transmission.

4.8.1.4 Ice detection principle schematics

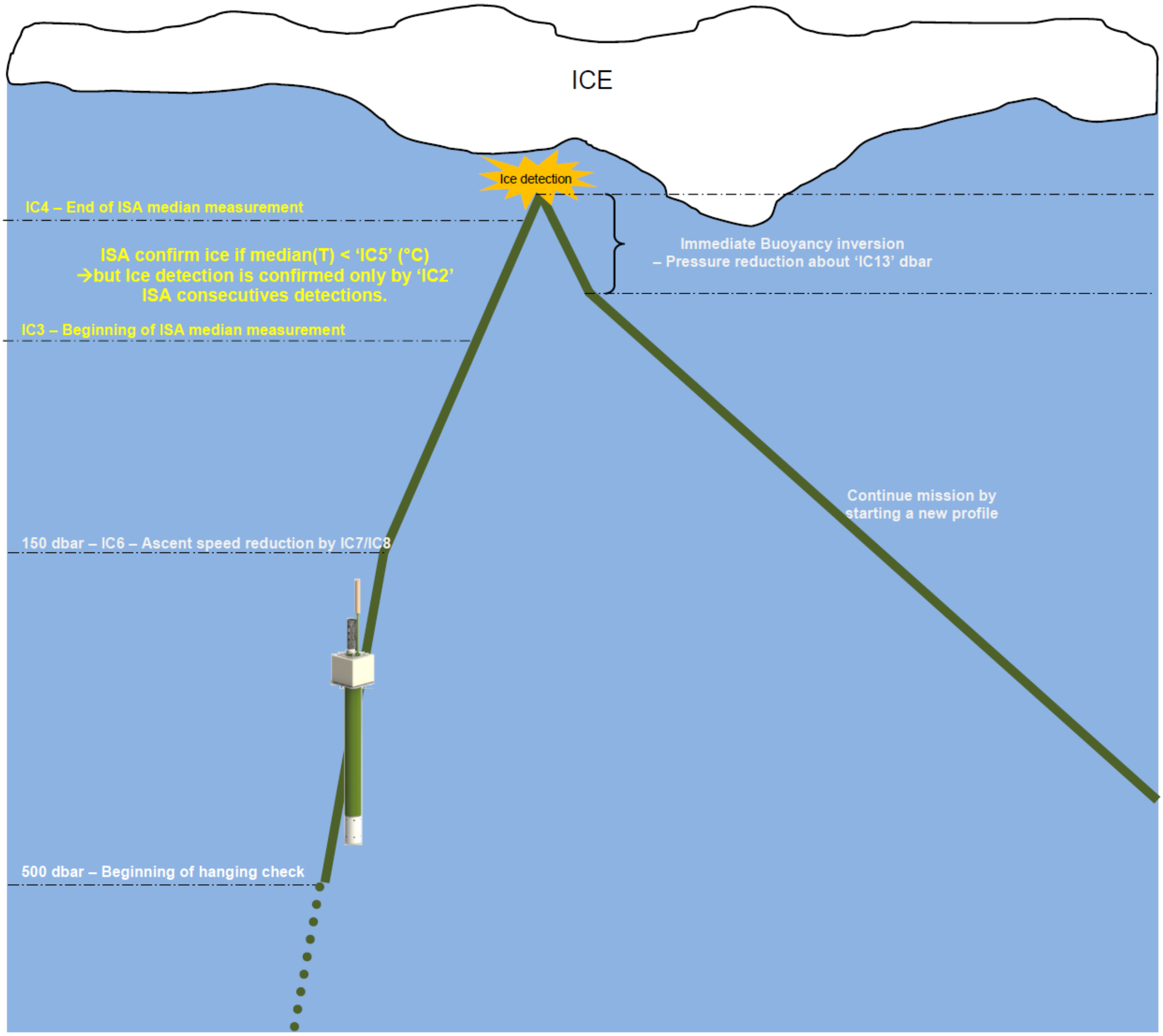


Figure 5 – Ice detection mechanisms

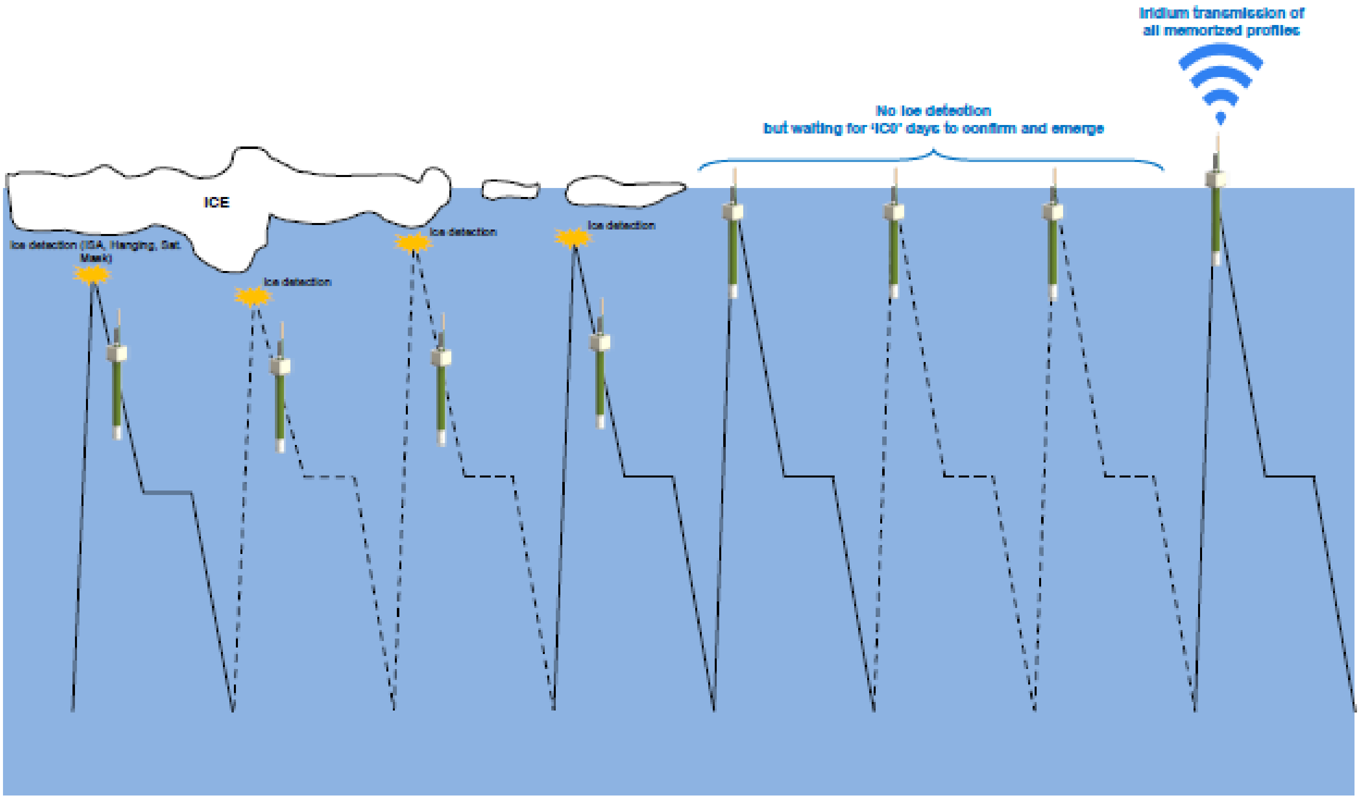


Figure 6 – Transmission after ice detection principle

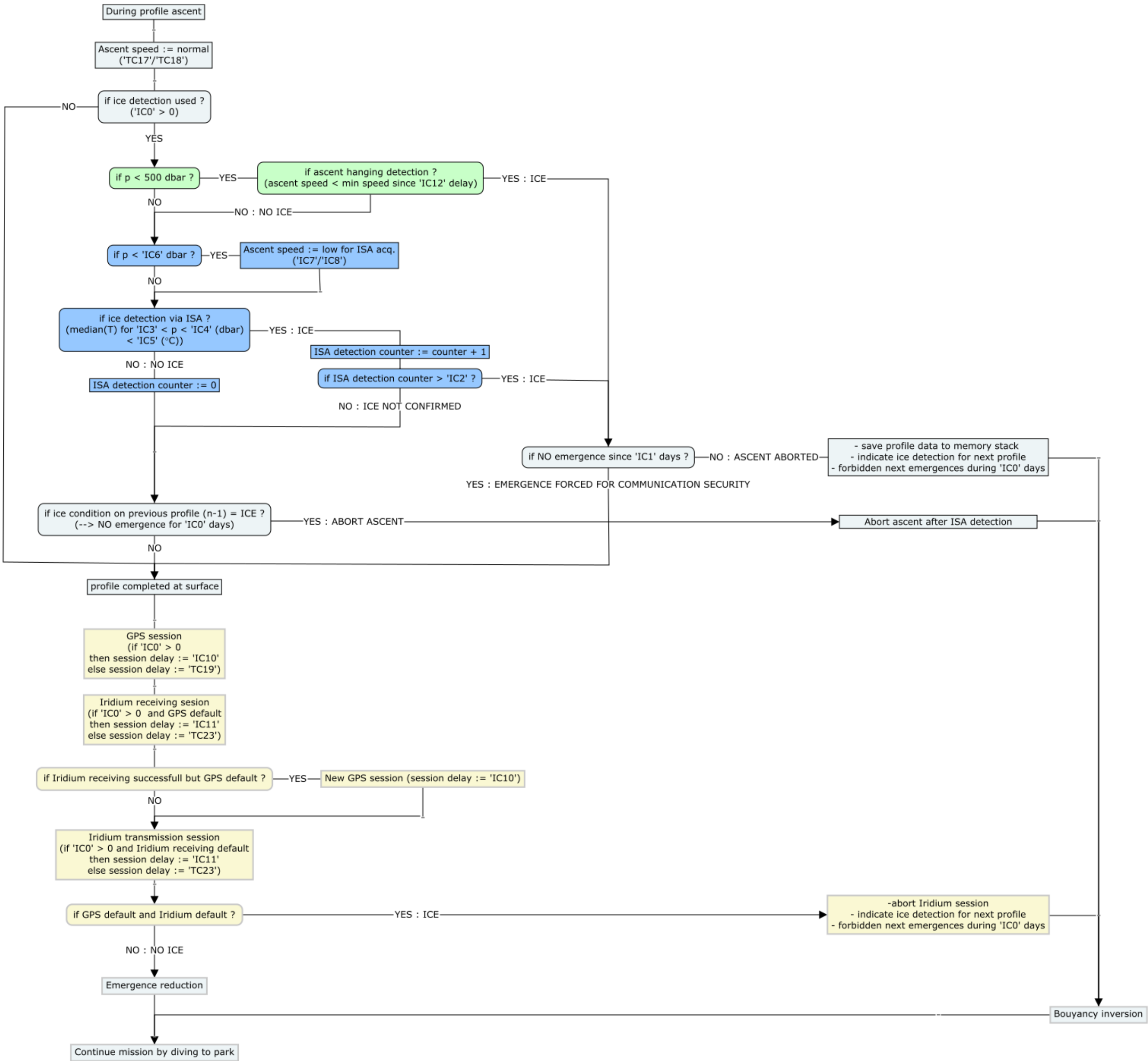
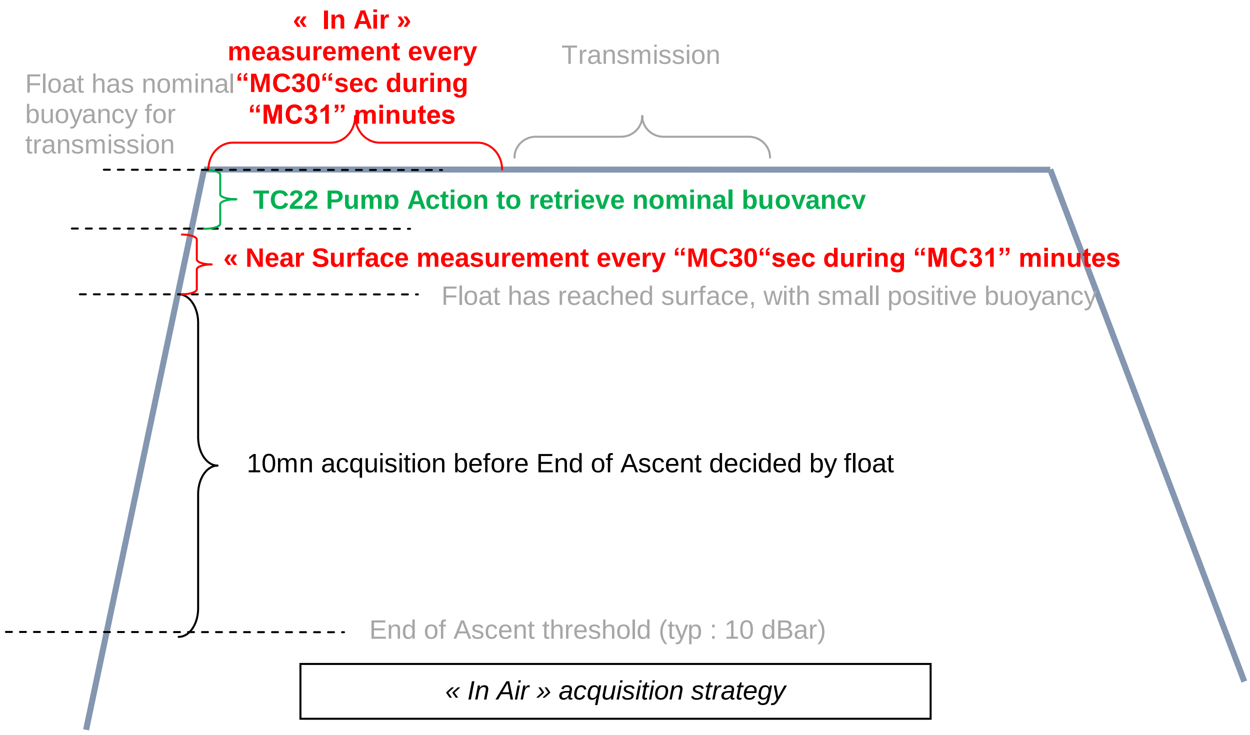


Figure 7 –Ice detection Synoptic

4.9 "Near Surface" and "In Air" measurement

User can choose to set-up this kind of measurement or not. "In Air" measurement enables dissolved oxygen verification once float reaches surface. A few measurements are done as float is "Near Surface" and also after float retrieves maximal buoyancy (after final pump action : "In Air"). Three parameters are used to set-up measurements : MC29, MC30 & MC31. MC29 set up measurement periodicity over the cycles. MC29 = 1 means "In Air" measurement at each cycle. MC29 = 0 means no "In Air" measurement. MC29 = x means "In Air" measurement every "x" cycles. MC30 set-up interval between each "In Air" sample, and MC31 set-up duration for "In Air" acquisition.

"Near Surface" measurements are sampled just before the final pump actions phase (that give float nominal buoyancy at surface). "In Air" measurements are sampled just after this final pump actions phase. Both samples are transmitted in SBD packets.



« In Air » acquisition strategy

4.10 Transmission

The data transmission process takes into account the limitations of the IRIDIUM data collection system, including:

- the flight frequency of the satellites above the experiment zone;
- the uncertainty of the float's antenna emerging in rough seas;
- radio propagation uncertainties due to weather conditions, and;
- the satellites' operational status.

ARVOR-I creates transmission messages from the stored "Treated data" (see 6.14 CTD(O) data treatment details) for treatment details. User can introduce a 2nd Iridium session with a delay specified with mission command 23 (MC23). In case MC23 is different from zero, floats transmits first all CTD data and technical message, and then waits for MC23 minutes before initiating a 2nd Iridium transmission. GPS position is updated. During 2nd session, only technical messages are transmitted. This 2nd session can be useful, in case user want to modify one or several mission parameters after data have been examined (in a very short delay).
With ice detection evolution, float is able to store SBD packet for transmission on following surfacing, in case for example of bad weather conditions or ice at surface. For this reason, cycle number is included in every packet.

5 ARVOR-I PARAMETERS

ARVOR-I's configuration is determined by the values of its mission parameters defined below. Instructions on how to read and change the values of these parameters are provided in **section 2.6.5. page 18.** The following table summarizes all parameter names, ranges and default values (Software YLA5900Y0x).

Command no.	Name	Default Value	Units	Min. Value	Max. Value
	Mission Commands				
MC0	Total number of cycles	300	Whole number	0	999
MC1	Number of cycles with cycle period 1	300		0	999
MC2	Cycle period 1	240	Hours	1	480
MC3	Cycle period 2	240	Hours	1	480
MC4	Reference day	2	Number of days	0	40
MC5	Expected time at the surface	6	Hours	0	23
MC6	Delay before mission	0	Minutes	0	1440
MC7	CTD sensor acquisition mode			1	4
MC8	Descent sampling period	0	Seconds	0 (**)	600
MC9	Drift sampling period	12	Hours	0	240
MC10	Ascent sampling period	10	Seconds	8	600
MC11	Drift depth for “MC1” first cycles	1000	dBar	0	2020
MC12	Profile depth for “MC1” first cycles	2000	dBar	0	2020
MC13	Drift depth after “MC1” cycles are done	1000	dBar	0	2020
MC14	Profile depth after “MC1” cycles are done	2000	dBar	0	2020
MC15	Alternated profile period	1		1	20
MC16	Profile pressure of alternated profile	2000	dBar	0	2020
MC17	Threshold surface/Intermediate Pressure	10	dBar	0	2000
MC18	Threshold Intermediate /Bottom Pressure	200	dBar	0	2000
MC19	Thickness of the surface slices	1	dBar	1	1000
MC20	Thickness of the intermediate slices	10	dBar	1	1000
MC21	Thickness of the bottom slices	25	dBar	1	1000
MC22	Iridium End of Life transmission period	60	Minutes	2	7200
MC23	2nd iridium session wait period	0	Minutes	0	360
MC24	Grounding mode (0: shift, 1: stay grounded)	0		0	1
MC25	Grounding switch pressure	50	dBar	10	200
MC26	Delay after grounding at surface	1	Minutes	0	2400
MC27	Optode type (0: none, 1: 4330, 2: 3830)	0		0	2
MC28	CTD sensor Cut-Off pressure (Pump stop)	5	dBar	2	60
MC29	“In Air” acquisition cycle periodicity	0		0	250
MC30	“In Air” acquisition sampling period	30	Seconds	10	300
MC31	“In Air” acquisition total duration	5	Minutes	0	3600

Table 5 - Summary of ARVOR-I user-programmable parameters

(*) : User should not program value over these limits. Risk for float integrity could be created if done.
(**) : “0” for descent sampling rate means no acquisition. If acquisition is requested, minimum value is 8 seconds.

5.1 Mission commands

MC(0) Total number of cycles

This is the total number of cycles of descent, submerged drift, ascent and transmission that ARVOR-I will perform. The mission ends and ARVOR-I enters Life Expiry mode (EOL mode) when this number of cycles has been completed. If set to "0", float enters in EOL immediately after buoyancy reduction phase

The capacity of ARVOR-I 's batteries is sufficient for at least 300 cycles (depending on Battery type and volume of CTD data to be acquired and transmitted). If you wish to recover ARVOR-I at the end of the mission, you must set the number of cycles at less than 300 to ensure there is sufficient battery capacity remaining to allow ARVOR-I to return to the sea surface and enter Life Expiry.

Under favourable conditions, the battery capacity may exceed 300 cycles. If you do not plan to recover the ARVOR-I float, you may choose to set the number of cycles to 300 to ensure that ARVOR-I completes the maximum number of cycles possible.

MC(1) Number of cycles with "Cycle period 1"

During "MC 1" first Cycles, float realizes profile using commands : "MC2", "MC11" & "MC12". During the first "MC1" cycle(s), cycle period is "MC2" hours. Once the first "MC1" cycles are performed, float switches to "MC3" hours as cycle period, and uses "MC13" & "MC14" for Parking depth and Profile depth.

MC(2) Cycle period 1 (hours) *

The duration of one cycle of descent, submerged drift, ascent and transmission. ARVOR-I waits submerged at the drift depth for as long as necessary to make the cycle the selected duration. This parameter is used during the "MC1" first cycle of the mission

MC(3) Cycle period 2 (hours) *

The duration of the cycles that follow the first "MC1" ones. ARVOR waits submerged at the drift depth for as long as necessary to make the cycle the selected duration. This cycle period is applied to float once "MC1" cycles have been done up to total number of cycle (given by "MC0"). If previous cycle period ("MC2") was not modulo 24hours and "MC3" is modulo 24hours, next hour at surface (for following cycles) will be programmed with "MC5".

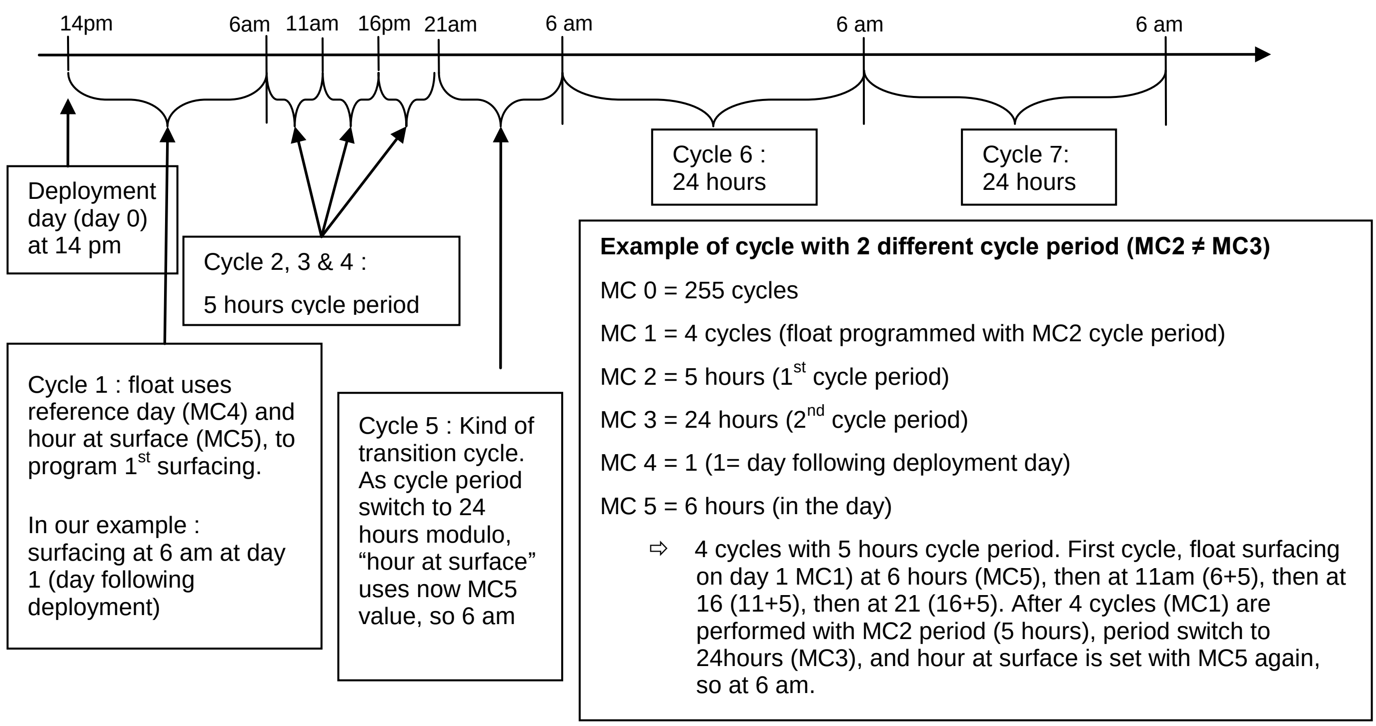


Figure 8 : Cycle period description

MC(4) Reference day (number of days)

The float's internal clock day number is set to zero when the mission starts. When this float day number equals the reference day "MC4", the float performs its first profile.
Thus, as this parameter defines a particular day on which the first profile is to be made, it allows you to configure a group of floats so that they all conduct their first profile at the same time.
When setting the reference day, it is recommended to allow enough time between the deployment and reach of profiling depth. Using a reference day of at least 2 will ensure the first profile to be completed.
If reference day is set to 0 or 1, float will probably not have enough time to reach Profile pressure target. In that case, float will shorten descent in order to stay in compliance with hour at surface. It means also that CTD acquisition during 1st descent could not occur, as float will enter earlier than expected in descent to profile (CTD acquisition is only during descent to parking depth).

MC(5) Expected time at the surface (hours)

Expected time float must reach surface.

MC(6) Delay before mission (minutes)

To prevent ARVOR-I from trying to sink while still on deck, the float waits for this time before commanding the buoyancy engine to start the descent. After disconnection of the PC, followed by removal of the magnet, ARVOR-I waits for this delay before beginning the descent. The delay is measured after the first start of the pump which confirms the removal of the magnet (see **section 2.4.1**) and before the start of the descent.

MC(7) CTD sensor acquisition mode

1 = Continuous pump mode (recommended), CTD pump will be active during complete profile
2 = ECO Mode (measurement is taken in the middle of the theoretical slice).
3 = Mix-mode (ECO mode in Deep zone, Continuous pump mode in intermediate & shallow zone)
4 = Spot-sampling mode (pump is active for 20s approx, then sample is acquired)

With mode, 2, 3 and 4, slice thickness must be programed to stay greater than 5 dBar.
For thin slice thickness (< 5 dBar), continuous mode is needed.

MC(8) Descent sampling period (seconds)

The time interval between successive CTD measurements (raw data) during descent.
If this parameter is set to 0 seconds, no profile is carried out during the descent phase. Nevertheless, due to the ARGO requirements, the first descent profile of the mission is automatically done (at a 10 seconds sampling period) even if the parameter is equal to 0. Minimum value is 8 seconds.

MC(9) Drift sampling period (hours)

The time interval between successive CTD measurements during ARVOR-I 's stay at the drift depth.

MC(10) Ascent sampling period (seconds)

The time interval between successive CTD measurements (raw data) during ascent. Minimum value is 8 seconds.

MC(11) Drift depth used during "MC1" first cycle (dbar) **

The depth at which ARVOR-I drifts after completion of a descent while awaiting the time scheduled for the beginning of the next ascent.

MC(12) Profile depth used during "MC1" first cycle (dbar) **

Depth at which profiling begins if in an ascending profile. If ARVOR-I is drifting at some shallower depth, it will first descend to the profile depth before starting the ascent profile.

MC(13) Drift depth used with cycle period MC2 (dbar) **

The depth at which ARVOR-I drifts after completion of a descent while awaiting the time scheduled for the beginning of the next ascent.

MC(14) Profile depth used with cycle period MC2 (dbar) **

Depth at which profiling begins if in an ascending profile. If ARVOR-I is drifting at some shallower depth, it will first descend to the profile depth before starting the ascent profile.

MC(15) Alternate profile period

Period for float to make profile with "MC16" dBar as profile pressure instead of "MC12" or "MC14" dBar.
If MC15 = 1, float do not realize alternate profiles
If MC15 = 2, float will perform one profile with "MC12" (or "MC14") dBar as profile pressure and one profile with "MC16" dBar as profile pressure

If MC 15 = n, floats will perform (n-1) profiles with “MC12” (or “MC14”) dBar as profile pressure and 1 profile with “MC16” dBar as profile pressure.

MC(16) Alternate profile pressure (dBar)
Pressure used as profile pressure for alternated profiles

MC(17) Threshold Surface/Intermediate pressure (dbar) **
The isobar that divides surface depths from intermediate depths for the purpose of data reduction.

MC(18) Threshold Intermediate/Bottom pressure (dbar) **
The isobar that divides intermediate depths from deep depths for the purpose of data reduction.

MC(19) Thickness of the surface slices (dbar) **
Thickness of the slices for shallow depths (algorithm of data reduction).

MC(20) Thickness of the intermediate slices (dbar) **
Thickness of the slices for intermediate depths (algorithm of data reduction).

MC(21) Thickness of the bottom slices (dbar) **
Thickness of the slices for deep depths (algorithm of data reduction).

MC(22) Iridium End Of Life transmission period (minutes)
Transmission period (in hours) once float is in “End Of Life” mode (all programmed cycles have been reached). Float sends technical SBD messages only.

MC(23) 2nd Iridium session wait period (min)
At beginning of cycle, if this parameter is different from zero, 2 SBD sessions will occur. This enables to check if a change on mission or technical parameters has been correctly treated by float and if new parameters are effective for next cycle. After the 1st transmission, float waits for MC23 minutes before proceeding the 2nd transmission.

MC(24) Grounding mode
MC24 = 0 means shift, MC24 = 1 means float stay grounded.

MC(25) Grounding switch pressure
In case of grounding during descent to parking depth, float will reduce target pressure from MC25 dBars.

MC(26) Delay in case of grounding at surface (minutes)
In case of grounding during buoyancy reduction phase, float will wait during MC26 minutes before starting a new cycle.

MC(27) Optode type
Set optode type mounted on float, 0: 3830, 1: 4330, 2: none (case of standard CTD float).

MC(28) CTD Cut-Off pressure (dBar)
Programmed pressure for CTD pump stop. If programmed with low value, risk to introduce dirt and fooling in conductivity cell highly increases. It is recommended not to program value inferior to 5 dBar.

MC(29) “In Air” acquisition cycle periodicity
Cycle periodicity for “In Air” acquisition to be executed.
0 means no “In Air” acquisition
1 means “In Air” acquisition every cycle
X means “In Air” acquisition one cycle every “x” cycles

MC(30) “In Air” acquisition sampling period (seconds)
Delay between each CTD sample acquired during “Near Surface “ & “In Air” acquisition phase

MC(31) “In Air ” acquisition total duration (minutes)
Total duration for “In Air” acquisition (same for “Near Surface” acquisition).

***** Cycle period can be set to inferior value than 24H. In that case, float will wait hour at surface for 1st cycle, and then will realize cycles every cycle period.

Example : cycle period is 8H, and hour at surface is 14h (MC5) on day 1 (given by MC4). After deployment, at 1st cycle, float will be at surface at “MC5” hour, on day “MC4”. Then, float will cycle every 8 hours.

In our example, float is deployed on 20/12/2013. Float will be at surface at 14:00 pm on 21/12/2013 for 1st cycle, then, at surface on 21/12/2013 at 22:00 pm, then , on 22/12/2013 at 6:00 am, ...

Cycle period must be in compliance with parking depth, profile depth, average descent and average ascent speed. Average descent speed is 27 mm/sec, and ascent speed is 90 mm/sec.

So, float cannot realize cycle at 2000 dBars every 12 hours for example.

** ARVOR-I can transmit up to 2015 samples per cycle. Theoretical number of samples to be acquired can be estimated based on different threshold between 3 zones and on slices thickness.

5.2 Ice detection commands

	Command no.	Name	Default Value	Units
	Ice detection commands			
	IC0	Number of days without surface emergence if ice detected	10	1 day
	IC1	Number of days before surface emergence even with ice detected	90	1 day
ISA	IC2	Number of detections to confirm ice at surface	3	1 detection
	IC3	Start pressure detection	50	1 dBar
	IC4	Stop pressure detection	20	1 dBar
	IC5	Temperature threshold	-1790	0.001°C
	IC6	Slowdown pressure threshold	150	1 dBar
	IC7	Pressure acquisition period during ascent (slow speed), once P < IC6	2	1 minute
	IC8	Pressure delta min before pump action	4	1 dBar
	IC9	Pump action duration	500	0.01 second
Satellite criteria	IC10	GPS timeout	5	1 minute
	IC11	1st Iridium lock timeout	10	1 minute
Ascent blocking	IC12	Delay before ascent blocking detection	30	1 minute
Buoyancy inversion	IC13	Pressure variation for buoyancy inversion	20	1 dBar
	IC14	Volume of valve action volume for buoyancy inversion	9	1 cm3
	IC15	Max volume before grounding detection (while in buoyancy inversion phase)	900	1 cm3

IC(0) Number of days without ascent if ice detected
This is the total number of days for float (after ice detection is confirmed, so after IC2 ISA detection), to disallow emergence.

IC(1) Number of days before ascent even with ice detected
This is the maximum number of days for float before transmission, even if ice is detected during ascent on several cycles This mechanism enables float to emerge and try to transmit in order not staying drifting for infinite period.

IC(2) Number of detection to confirm ice at surface
This is the number of ice detection with ISA algorithm to confirm ice at surface. This is used to prevent from false detection.

IC(3) Start pressure detection (dBar)
This is the pressure for float to start ISA algorithm for ice detection.

IC(4) Stop pressure detection (dBar)
This is the pressure for float to stop ISA algorithm for ice detection.

IC(5) Temperature threshold (0.001° C)
Temperature threshold for ice detection with ISA algorithm. If Temperature is inferior to IC5 value, ice detection is positive.

IC(6) Slowdown pressure threshold (dBar) *
This is the pressure threshold for float to decrease ascent speed to prepare for ISA detection method.

IC(7) Pressure acquisition period during ascent (slow speed), once P < IC6 (dBar) *
The time interval for minimum pressure variation (IC8 dBar) verification. If (with default values),real pressure variation is inferior to IC8 during IC7 minutes, float activates hydraulic pump (4 dBar / 2 Minutes = 2 dBar/min or 3.33 cm/sec).

IC(8) Pressure delta min before pump action (dBar) *
This is the minimum pressure variation (during IC7 minutes), before float activates pump (duration : IC9).

IC(9) Pump action duration (0.01 second) *
This is the pump action duration, once pressure is inferior to IC6 value (if ice detection is requested). Replace TC3 in ISA area (from IC3 to IC4 dBar).

IC(10) GPS timeout (Minute) *
This is maximum time for GPS to acquire good fix, in case ice detection is requested.

IC(11) 1st Iridium lock timetout (Minute) *
This is maximum time for Iridium modem to acquire good fix, in case ice detection is requested. Once fix is done, for transmission, timeout becomes TC23 (as transmission has started, surface is free of ice, so float uses standard Timeout).

IC(12) Delay before ascent blocking detection (Minute) *
This is the delay for float to detect ascent blocking.

IC(13) Pressure variation for speed inversion(dBar) *
This is the pressure delta to detect that float has finished buoyancy inversion.

IC(14) Valve action volume (cm3) *
This is the unit volume of each valve action during buoyancy inversion phase.

IC(15) Max valve volume to detect grounding on descent *
This is the maximum volume for valve action during buoyancy inversion

*: all these parameters requires good expertise and float technical knowledge for modification. It is recommended to contact nke instrumentation for modification.

5.3 User commands (terminal commands to float)

These commands are used to dialog with float during preparation phase, to make test (sensor, GPS, Iridium,…) or to program float parameters for coming mission. These commands requires Bluetooth connection to float.

User commands can be request to float with command :

?HE

Float will answer will available command list

Command	Rôle
!AR x ***	Arm float (x=1) or deactivate arm mode (x=0) **MUST BE ON FOR DEPLOYMENT**
?AR	Request “armed mode” state
!C x	Float complete auto-test. X = 0 or 1. Is X=1, a complete auto-test is done. If x=0, buzzer won’t be activated
?CK	Firmware checksum check
!CU	Program SBE41 Cut-Off Pressure value according to technical command
?DH	Read all hydraulic data (pump and electrovalve activations) acquired during last mission (cf chap 6.13.1Phase description to check kind of acquired data)
?DT	Read all Treated Data acquired during last mission (cf chap 6.13.1Phase description to check kind of acquired data)
?DB	Read all Raw Data acquired during last mission (cf chap 6.13.1Phase description to check kind of acquired data)
!E x	Activate electrovalve for x cs (ctrl-c to stop)
?FP	Fast Pressure request (Pressure measurement only)
?HE	Help command. Float will screen all available user commands
!IC x y	Set value y for “ice command” x
?IC	Screen all ice commands
?IC x	Screen ice command x
!K x	Command to activate or deactivate read/Write access for technical parameters. X value is communicated to users upon request to nke
!MC x y	Set value y for “mission command” x
?MC	Screen all mission commands
?MC x	Screen mission command x
?NS	Request float’s serial number
!P x**	Activate pump for x cs (ctrl-c to stop)
!PB	Request Battery Voltage with hydraulic pump active
?RE	Read the 5 last reset date and time
?RO	SBE Pressure sensor last resetoffset value(deciBars)
!RO	SBE Pressure sensor resetoffset operation (take one minute)
!RP	Parameters are transferred from EEPROM memory to RAM memory
?S	CTD sensor acquisition
!SE	Initiate GPS acquisition and IRIDIUM transmission session (requires satellite visibility

?SP	Read all Data (Treated & Raw CTD data, hydraulic data)
!SH x	Activate (x=1) or de-activate (x=0) Show mode **(MUST BE OFF FOR DEPLOYMENT)**
?SH	Request show mode state
!TB x	Activate buzzer for x seconds. To stop buzzer before 'x' seconds, send command !TB 0
?TI	Request float's internal date and time
!TR	SBE41 transparent dialog mode
!TC x y *	Set value y for "technical parameter" x
?TC *	Screen all technical commands
?TC x *	Screen technical command x
!TI dd mm yy hh mn ss	Set date and time to dd/mm/yy hh:mn:ss
!V	Float measure Internal vaccum and refresh value every 5 seconds
?VB	Request internal vacuum and battery voltage (in decivolt and millibar)
?VL	Request software version

Table 6 - User command list

* : protected command (need !K *x* to unlock)

** : Float is delivered with hydraulic pump priming (fill in with oil). Pump must not be activated for long period as external bladder is already full

*** : As Armed Mode command is sent to float, float performs an auto-test, that enables to check a last time that everything is OK for float's deployment

6 IRIDIUM FORMATS

6.1 Overview

The data transmission process begins as soon as an ascent profile is completed. It starts with reduction of the data. ARVOR-I then formats and transmits the message. The reduction of data processing consists in storing the significant points of the CTD triplets arithmetic mean with the layer format.

SBD message contains one, 2 or 3 packets. One packet is a 100 bytes length

Message (up to 3 packets)	Packet 1	Packet 2	Packet 3

Different types of packets are generated according to the content of the data frame:

Packet type number	Message Type
0	Technical packet n°1
1	Descent CTD packet
2	Drift CTD packet
3	Ascent CTD packet
4	Technical packet n°2
5	Float parameter packet
6	Hydraulic packet
7	Float parameter n°2 packet
8	Descent CTDO packet
9	Drift CTDO packet
10	Ascent CTDO packet
11	CTDO « Near Surface » packet
12	CTDO « In Air » packet
13	CTD « Near Surface » packet
14	CTD « In Air » packet

⇨ **300 bytes message N°1 sent**

300 bytes message N°2 sent

⇨ **100 or 200 or 300 bytes message N°n sent (size of last message depends on remaining packet number)**

The types of CTD(O) messages all contain recorded physical measurements. The technical messages contains data regarding the configuration and functioning of the float and its buoyancy control mechanism. Parameter message contains information regarding programmed “mission and technical commands”. Hydraulic messages contains data regarding electro-valve and pump activations during cycle

The message type is formed from bits 1 to 4 of the data frame. The formatting of the data frame for each message type is described in the pages that follow.

Each time float arrives at surface it proceeds an “Iridium session” which consists of :

- GPS point acquisition
- Telecommands reception and treatment.
- Data transmission (CTD(O) packets, technical packets, hydraulic and parameter packets)

Float can proceed to 2 Iridium session each time it arrives on surface. 2nd session is optional, depending on mission parameter “Inter-cycles wait period” value. This parameter specifies delay between end of 1st iridium session and beginning of 2nd iridium session. By default this parameter is set to zero, meaning that float will only proceed to one Iridium session.

If this parameter is set to a different value than zero, a 2nd session will be done in a delay specified by “Inter-Cycles Wait Period” parameter.

During 2nd session, only technical and parameters packets will be send.

The 2nd session enables to modify float parameters before beginning of following cycle and after data analysis (data received during 1st session).
Telecommands can be sent before float arrives at surface, or before 2nd session only. It seems that telecommands must be sent maximum 4 days before floats arrives on surface. If telecommand is sent before this delay, it could be erased from Iridium queue and not be delivered as expected.

One telecommand can now include modification for several parameter -> One telecommand = 10 parameter max to modify. See chapter 6.18.2 page 64 for details about Iridium telecommands.

Version YLA5900A05 and higher :
The parameters packets will only be send on the first session before deployment and each times that the float will receive Iridium telecommands.

If the float has been deployed within the framework of the Argo project (http://www.argo.ucsd.edu/), the decoded data are available in one of the 4 NetCDF files (META, PROF, TRAJ, TECH) used by the Argo data management to store and diffuse the information (see http://www.argodatamgt.org/Documentation for details).

Behaviour with ice detection : In case float has stored packets because of ice detection, during transmission; float first transmits current cycle data, then, all previous cycles data starting with the most ancient one.

Ex : float could not transmit cycle #52 to #58 data because of ice, and transmission restart at cycle #59 : float will transmit cycle #59 data, then data from cycle #52, #53, up to #58.

6.2 Technical packet (type = 0)

	Data	Nb bytes	Resolution
0	Type (= 0)	1	
	General information		
1	Cycle number	2	1 cycle
2	Iridium session number	1	
3	Float's firmware checksum	2	
4	Float serial number	2	
	Emergence reduction		
5	Day of beginning	1	1 day
6	Month of beginning	1	1 month
7	Year of beginning	1	1 year
8	Relative start day (to mission's beginning)	2	1 day
9	Cycle start time	2	1 min
10	Hydraulic 1st action duration at surface	2	1 sec
11	Number of simple valve actions at the surface	1	
12	Grounded at surface flag	1	
	Descent to parking depth		
13	Descent to parking depth start time	2	1 min
14	Float first stabilisation time during descent to parking depth	2	1 min
15	Descent to parking depth end time	2	1 min
16	Number of valve actions during descent to parking depth	1	
17	Number of pump actions during descent to parking depth	1	
18	Float first stabilisation pressure during descent to parking depth	2	1 dbar
19	Max pressure during descent to parking depth	2	1 dbar
	Parking drift phase		
20	Beginning drift phase at parking depth absolute day	1	1 day
21	Number of entrance in drift target range (descent)	1	
22	Number of repositions during drift at parking depth	1	
23	Minimum pressure during drift at parking depth	2	1 dbar
24	Maximum pressure during drift at parking depth	2	1 dbar
25	Number of valve actions during drift at parking depth	1	
26	Number of pump actions during drift at parking depth	1	
	Descent to profile depth		
27	Descent to profile depth start time	2	1 min
28	Descent to profile depth end time	2	1 min
29	Number of valve actions during descent to profile depth	1	
30	number of pump actions during descent to profile depth	1	
31	Max pressure during descent to profile depth	2	1 dbar
	Profile drift phase		
32	Number of entrance in drift target range	1	
33	Number of repositions during drift at profile depth	1	
34	Number of valve actions during drift at profile depth	1	
35	Number of pump actions during drift at profile depth	1	
36	Minimum pressure during drift at profile depth	2	1 dbar

37	Maximum pressure during drift at profile depth	2	1 dbar
	Ascent phase		
38	Ascent start time	2	1 min
39	Transmission start time (hh+mm+ss)	2	1 min
40	Number of pump actions during ascent	1	
	General information		
41	Float time (hh+mm+ss)	3	1h, 1min, 1sec (1 byte each)
42	Float date (dd+mm+yy)	3	1day, 1month, 1year (1 byte each)
43	Pressure sensor offset (two's complement coded)	1	1 cbar
44	Internal pressure	1	5 mbars
45	Batteries voltage drop at Pmax, pump ON (with regard to Unom = 15.0 V)	1	0.1 V
46	RTC state indicator (normal = 0, failure = 1)	1	
47	Coherence problem counter	1	
48	Oxygen sensor status (0 = ok, 1 = problem, 2 = none)	1	
	GPS Data		
49	GPS latitude in degrees	1	1 degree
50	GPS latitude in minutes	1	1 minute
51	GPS latitude in minutes fractions (4^{th})	2	1 minute fraction (4^{th})
52	GPS latitude orientation (0 = North, 1 = South)	1	
53	GPS longitude in degrees	1	1 degree
54	GPS longitude in minutes	1	1 minute
55	GPS longitude in minutes fractions (4^{th})	2	1 minute fraction (4^{th})
56	GPS longitude orientation (0 = East, 1 = West)	1	
57	GPS valid fix (1 = valid, 0 = not valid)	1	
58	GPS session duration	2	1 sec
59	GPS session timeout (change in version 5900A03 & higher)	1	1 minute
60	Pump duration (buoyancy retrieve for GPS acquisition)	2	1 sec
61	Antenna status (0 = don't know, 1 = ok, 2 = short, 3 = open)	1	
	End Of Life information		
62	End Of Life detection flag	1	
63	End Of life start hour	3	1h, 1min, 1sec (1 byte each)
64	End Of life start Date	3	1day, 1month, 1year (1 byte each)
	System information		
65	System calendar retiming (YLA5900A05 and higher)	2	1sec
66	Not used (filled by zeros)	1	
	Total	100	

Table 7 - Technical message

6.3 Technical packet 2 (type = 4)

	Data	Nb bytes	Resolution
0	Type (=4)	1	
	General information		
1	Cycle number	2	1 cycle
2	1st or 2nd session indicator (0 = 1st session, 1 = 2nd session)	1	
	Data nformation		
3	Number of descent CTD(O) packets	1	1 packet
4	Number of drift CTD(O) packets	1	1 packet
5	Number of ascent CTD(O) packets	1	1 packet
6	Number of “Near Surface” CTD(O) packets	1	1 packet
7	Number of “In Air” CTD(O) packets	1	1 packet
8	Number of descent slices in shallow zone	2	
9	Number of descent slices in deep zone	2	
10	Number of CTD(O) measurements in drift	1	
11	Number of ascent slices in shallow zone	2	
12	Number of ascent slices in deep zone	2	
13	Number of “Near Surface” CTD(O) measurements	1	
14	Number of “In Air” CTD(O) measurements	1	
	Sub-surface point		
15	Sub-surface pressure	2	1 cBar
16	Sub-surface temperature	2	1 m°C
17	Sub-surface salinity	2	1mPSU
18	Sub-surface C1Phase	2	0,002°
19	Sub-surface C2Phase	2	0,002°
20	Sub-surface optode temperature	2	1 m°C
	Grounding		
21	Grounding number	1	
22	1st grounding pressure	2	1 dbar
23	1st grounding day (relative to cycle beginning)	1	1 day
24	1st grounding hour	2	1 min
25	1st grounding phase (*)	1	
26	Number of valve actions before 1st grounding detection	1	
27	2nd grounding pressure	2	1 dbar
28	2nd grounding day (relative to cycle beginning)	1	1 day
29	2nd grounding hour	2	1 min
30	2nd grounding phase (*)	1	
31	Number of valve actions before 2nd grounding detection	1	
	Emergency ascent		
32	Emergency ascent number	1	

33	1st emergency ascent time	2	1 min
34	1st emergency ascent pressure	2	1 dbar
35	Number of pump actions in emergency ascent	1	
36	1st emergency ascent day (relative to mission start day)	1	1 day
	Iridium remote control		
37	Number of remote files received	1	
38	Number of remote files rejected	1	
39	Number of remote commands received	1	
40	Number of remote commands rejected	1	
	Previous transmission information		
41	Previous Iridium transmission duration	2	1 sec
42	Number of SBD sessions for reception	1	
43	Number of SBD sessions for transmission	2	
	Miscellaneous		
44	Number of pump actions before float begins ascent	1	
45	Internal vacuum at ascent start-up	1	5 mbars
46	Last reset time : HH	3	1 sec
47	MM		
48	SS		
49	Last reset date : JJ	3	
50	MM		
51	AA		
52	Autotest (0 = problem, 1 = ok)	1	
53	Detailed autotest	2	
54	Parameter integrity test	1	
55	Positive buoyancy at deployment	1	
56	CTD Status (0: ok, 1: Fast Pressure default Time-Out, 2: Fast Pressure broken frame, 16: CTD default Time-Out, 32: CTD broken frame)	1	
57	Float phase during CTD default detection (*)	1	
58	Hydraulic type (0: ARVOR, 1: PROVOR)	1	
59	Ice detection flag (1: ISA, 2: satellite visibility, 4: ascent hanging) (added in packet from firmware version 5900A03 & following)	1	
60	Not used (filled by zeros)	20	
	TOTAL	**100**	**bytes**

(*) see chap 6.18.1 for phase description and associated numbers.

- Tech. Param #9, #13, #14, #15, #27,#28, #38 & #39 of tech. Msg 1 : all these time are expressed in minutes in the day since midnight.

6.3.1 General information

- Tech. Param #1 of tech. Msg 1 : The prelude phase and the first deep cycle are numbered 0.
- Tech. Param #41 of tech. Msg 1 : Floats' time is expressed with 3 bytes : Hour (1 byte) + Minute (1 byte) + seconds (1 byte).
- Tech. Param #43 of tech. Msg 1 : Pressure sensor offset is measured at the surface. Least significant bit = 1 cbar (two's complement coded). Range: -32 cbar to +31 cbar.
- Tech. Param #44 of tech. Msg 1 : Internal pressure is measured at the end of the ascent and before the Mission start. Measurements are given in 5 mbar steps.

6.3.2 Buoyancy reduction

- Tech. Param #11 of tech. Msg 1 : Number of solenoid valve actions at the surface until the crossing of the 8 dbar threshold is an integer from 1 to 255 (modulo 256).

6.3.3 Descent to parking depth

- Tech. Param #5, #6 & #7 of tech. Msg 1 : Calendar day, month & year for buoyancy reduction start.
- Tech. Param #10 of tech. Msg 1 : Hydraulic valve action duration before float switch to simple valve actions
- Tech. Param #11 of tech. Msg 1 : Number of solenoid valve actions at the surface until the crossing of the 8 dbar threshold is an integer from 0 to 255 (modulo 256).
- Tech. Param #13 of tech. Msg 1: Descent start time is expressed in minutes since midnight.
- Tech. Param #14 of tech. Msg 1 : Float first stabilisation time after the crossing of the 8 dbar threshold.
- Tech. Param #16 of tech. Msg 1 : Number of solenoid valve actions carried out to reach the target pressure after crossing the 8 dbar threshold.
- Tech. Param #18 of tech. Msg 1 : Float first stabilisation pressure after crossing the 8 dbar threshold.

6.3.4 Drift at parking depth

- Tech. Param #23 & #24 of tech. Msg 1 : Minimum and maximum pressure collected during the hydraulics measurements at parking depth, expressed in dbar.

6.3.5 Drift at profile depth

- Tech. Param #36 & #37 of tech. Msg 1 : Minimum and maximum pressure collected during the hydraulics measurements at profile depth, expressed in dbar.

6.3.6 Ascent

- Tech. Param #39 of tech. Msg 1 : Time at the end of the pump action after surfacing, just before the transmission starts.

  Ascent end time (i.e. crossing of the 1 bar threshold) occurs approximately [10 minutes + duration of the last pump action of the buoyancy acquisition phase (TC4)] before transmission start time.

- Tech. Param #40 of tech. Msg 1 : Number of pump actions in ascent (from the profile pressure until the crossing of the 1 bar threshold).

6.3.7 Data information

- Tech. Param #8 of tech. Msg 2 : Includes the sum of the data sampled in the shallow and the intermediate zones (descent profile).
- Tech. Param #9 of tech. Msg 2 : Includes the sum of the data sampled in the deep zone (descent profile).
- Tech. Param #11 of tech. Msg 2 : Includes the sum of the data sampled in the shallow and the intermediate zones (ascent profile).
- Tech. Param #12 of tech. Msg 2 : Includes the sum of the data sampled in the deep zone (ascent profile).

6.3.8 Sub-surface point

The sub-surface point is the last ‘raw’ CTD measurement sampled before the switch off of the CTD pump.

- Tech. Param #15 of tech. Msg 2: Pressure of the sub-surface point, coded in two’s complement (in cbar) with an offset of -10000 cBar.

To decode the transmitted (Pssp) value:

Pressure (dbar) = [two’s-complement of a 16 bits value (Pssp)+10000] /10.

- Tech. Param #16 of tech. Msg 2 : Temperature of the sub-surface point, coded in two’s complement (in m°C).

To decode the transmitted (Tssp) value:

Temperature (°C) = [two’s-complement of a 16 bits value (Tssp)] /1000.

- Tech. Param #17 of tech. Msg 2 : Salinity of the sub-surface point coded in m°PSU.

To decode the transmitted (Sssp) value:

Salinity (PSU) = Sssp /1000.

6.3.9 Grounding

- Tech. Param #23 & #28 of tech. Msg 2 : Number of days elapsed since the mission start day (modulo 256).

6.3.10 Emergency ascent

- Tech. Param #36 of tech. Msg 2 : Number of days elapsed since the mission start day (modulo 256).

6.3.11 Miscellaneous data

- Tech. Param #58 of tech. Msg 1 : Timing before GPS position is considered as valid. Expressed in seconds.
- Tech. Param #59 of tech. Msg 1 : **GPS session timeout is not used.**
- Tech. Param #60 of tech. Msg 1 : Additional pump activation during GPS acquisition, in case of insufficient buoyancy, is expressed with 2 bytes in seconds.
- Tech. Param #44 of tech. Msg 2 : Number of pump actions before float lift-up from profile pressure to start the ascent profile.
- Tech. Param #45 of tech. Msg 2 : Internal pressure is measured at the beginning of ascent profile. Measurements are given in 5 mbar steps starting from 700 mbar.
- Tech. Param #46, #47 & #48 of tech. Msg 2 : Time (hour+minute+ seconds) for float mission start, is expressed with 3 bytes : Hour (1 byte) + Minute (1 byte) + seconds (1 byte)
- Tech. Param #49, #50 & #51 of tech. Msg 2 : Calendar day, month & year for float mission start (1 byte each)
- Tech. Param #52 of tech. Msg 2 : Autotest flag: “0” means that initial auto-test at float’s deployment was not ok; “1” means that everything was ok.
- Tech. Param #53 of tech. Msg 2 : Detailed autotest: give information about sub-assemblies tested during auto-test.
- Tech. Param #55 of tech. Msg 2 : Positive buoyancy at deployment : “0” means float stays at surface at deployment; “1” means that float was heavy at deployment and began to sink immediately
- Tech. Param #56 & #57 of tech. Msg 2 : Give information about CTD sensor status, and float phase for default detection.

6.3.12 End Of Life information

- Tech. Param #62 of tech. Msg 1 : End Of Life detection flag, indicate if float has entered in End Of Life mode.
- Tech. Param #63 of tech. Msg 1 : Time (hour+minute+ seconds) for float End Of Life start (1 byte each).
- Tech. Param #64 of tech. Msg 1 : Date (day+month+year) for float End Of Life start (1 byte each).

6.4 Descent profile CTD packet (type = 1)

Data	Nb bytes	Resolution
Type (=1)	1	1
Cycle number	2	
1st CTD sample		
Date of the first CTD sample: Hours (2 bytes) Minutes (1 byte) Seconds (1 byte)	4	1 hour 1 minute 1 second
Pressure	2	0.1 dBar
Temperature	2	0.001°C
Salinity	2	1 mPSU
2nd CTD sample		
Pressure	2	0.1 dBar
Temperature	2	1 m°C
Salinity	2	1 mPSU
3rd CTD sample		
…	…	
15th CTD sample		
Pressure	2	0.1 dBar
Temperature	2	1 m°C
Salinity	2	1 mPSU
Not used (filled by zeros)	3	
TOTAL	100	

Table 8 - Descent CTD packet

The date of the first CTD sample is relative to the mission start day (float internal day number = 0).
The first 2 bytes provide the number of hours elapsed since mission start day.
The following byte provides the number of minutes and the last byte the number of seconds.

Pressure is coded in two’s complement (in cbar) with an offset of -10000 cBar

The Pn transmitted value can then be decoded with the equation:

Pressure (dBar) = [two’s-complement of a 16 bits value (Pn) + 10000] / 10.0

Temperature is coded in two’s complement (in m°C).

The Tn transmitted value can then be decoded with the equation:

Temperature (°C) = [two’s-complement of a 16 bits value (Tn)] / 1000.

Salinity is coded in mPSU.

The Sn transmitted value can then be decoded with the equation:
Salinity (PSU) = Sn / 1000

6.5 Submerged drift CTD packet (type = 2)

Identical to descent profile CTD packet with **type 2.**

6.6 Ascent profile CTD packet (type = 3)

Identical to descent profile CTD packet with **type 3.**

6.7 "Near Surface" CTD packet (type = 13)

Identical to descent profile CTD packet with **type 13.**

Float will transmit MC31 * 60 / MC30 measure for "Near Surface" acquisition **with a limit of 3 packets.**

6.8 "In Air" CTD packet (type = 14)

Identical to descent profile CTD packet with **type 14.**

Float will transmit MC31 * 60 / MC30 measure for "In Air" acquisition **with a limit of 3 packets.**

6.9 Descent profile CTDO packet (type = 8)

Depending on optode equipment or not (set with mission command MC27), float will transmit CTDO packets or not. In case, float is equipped with optode, these type of packets are transmitted instead of CTD packets (1, 2, 3, 13 & 14).

Data	Nb bytes	Resolution
Type (=8)	1	1
Cycle number	2	
1st CTD sample		
Date of the first CTDO sample: Hours (2 bytes) Minutes (1 byte) Seconds (1 byte)	4	1 hour 1 minute 1 second
Pressure	2	0.1 dBar
Temperature	2	0.001°C
Salinity	2	1 mPSU
C1Phase	2	0.002 °
C2Phase	2	0.002 °
Optode temperature	2	0.001 °C
2nd CTD sample		
…	…	
7th CTD sample		
Pressure	2	0.1 dBar
Temperature	2	1 m°C
Salinity	2	1 mPSU
C1Phase	2	0.002 °
C2Phase	2	0.002 °
Optode temperature	2	0.001 °C
Not used (filled by zeros)	9	
TOTAL	100	

Table 9 - Descent CTDO packet

The date of the first CTDO sample is relative to the mission start day (float internal day number = 0).

The first 2 bytes provide the number of hours elapsed since mission start day.

The following byte provides the number of minutes and the last byte the number of seconds.

Pressure is coded in two's complement (in cbar).with an offset of -10000 cBar

The Pn transmitted value can then be decoded with the equation:

Pressure (dBar) = [two's-complement of a 16 bits value (Pn) + 10000] / 10.0

Temperature is coded in two's complement (in m°C).

The Tn transmitted value can then be decoded with the equation:

Temperature (°C) = [two's-complement of a 16 bits value (Tn)] / 1000.

Salinity is coded in mPSU.

The Sn transmitted value can then be decoded with the equation:

Salinity (PSU) = Sn / 1000

C1 and C2 phases are coded with a 0.002° resolution and an offset of 40°.

The CPn transmitted value can then be decoded with the equation:

C1/C2Phase (angular degree) = [(CPn - 20 000) x 2] / 1000.

Optode temperature is coded in m°C with an offset of 5 000 m°C.

The OTn transmitted value can then be decoded with the equation:

Optode temperature (°C) = (OTn - 5 000) / 1000.

6.10 Submerged drift CTDO packet (type = 9)

Identical to descent profile CTDO packet with **type 9.**

6.11 Ascent profile CTDO packet (type = 10)

Identical to descent profile CTDO packet with **type 10.**

6.12 "Near Surface" CTDO packet (type = 11)

Identical to descent profile CTDO packet with **type 11.**

Float will transmit MC31 * 60 / MC30 measure for "Near Surface" acquisition **with a limit of 3 packets.**

6.13 "In Air" CTDO packet (type = 12)

Identical to descent profile CTDO packet with **type 12.**

Float will transmit MC31 * 60 / MC30 measure for "In Air" acquisition **with a limit of 3 packets.**

6.14 CTD(O) data treatment details

Before transmission, all data have to be treated. Depending on sampling period, number of acquired raw data per profile could be too high for good transmission. So raw data are treated with following strategy : Operation to convert raw data (CTD(O) samples) to “treated data” (CTD(O) data to transmit) consist in 2 successive operations to raw data : **Decimation & averaging** depending on **zone & Slice thickness**

6.14.1 Zone & slice thickness

User can define 3 zones with Threshold & Specific Slice Thickness (mission commands).

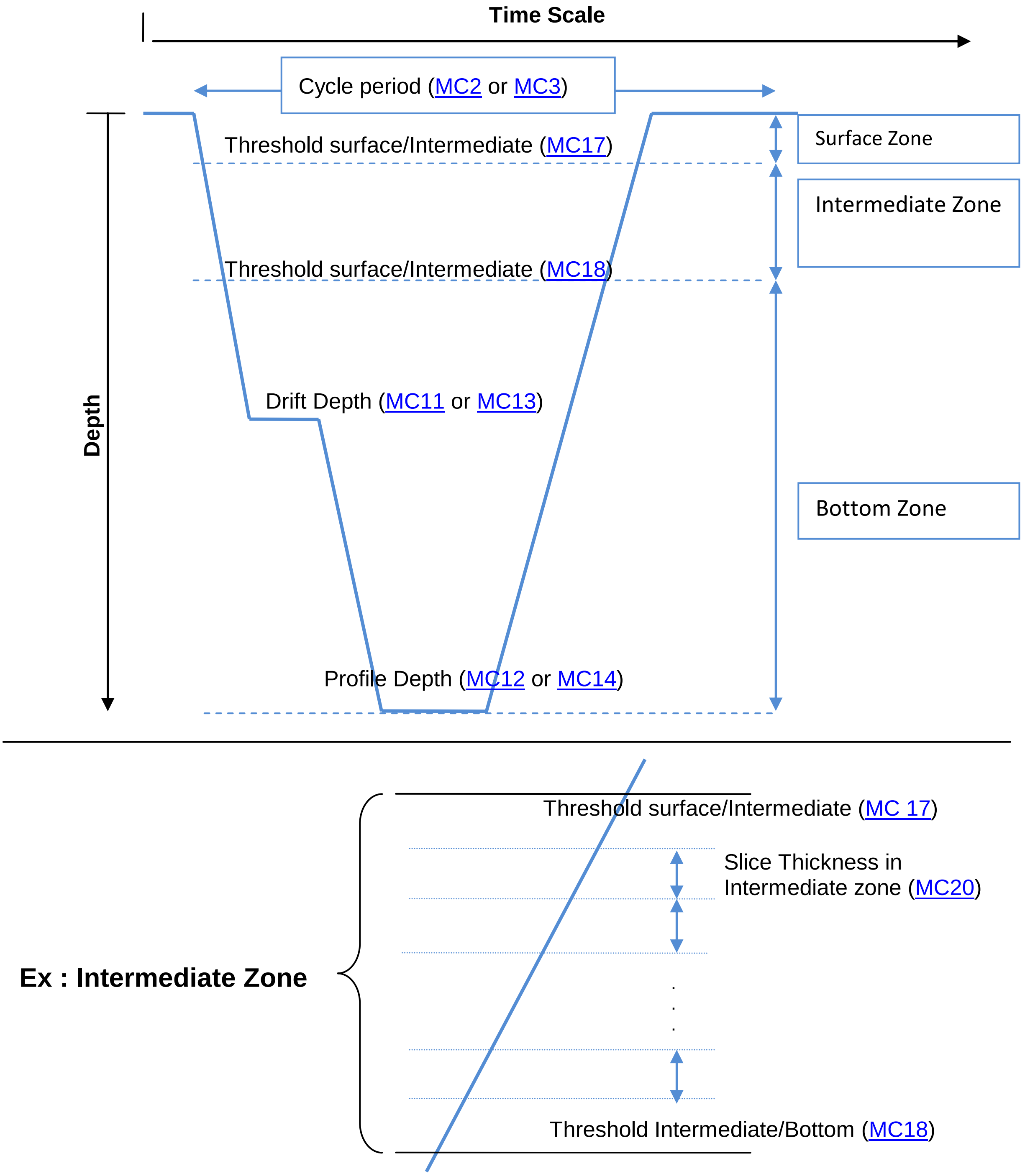


Figure 9- Zone & Slice thickness description

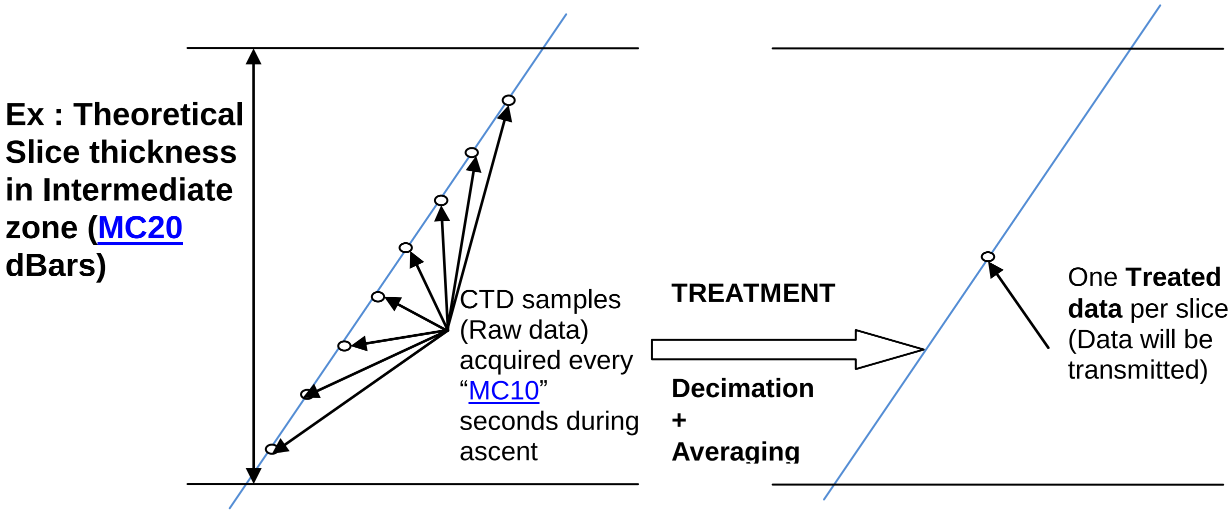


Figure 10 - Treatment description

6.14.2 Decimation

All raw data included in one theoretical CTD slice (defined with mission command depending on zone threshold and slice thickness in each zone) are filtered before proceed to averaging operation. Filter condition is that CTD samples must have 0.5 deciBar pressure variation (in the appropriate direction) with last kept CTD sample to be preserved.

Example : 5 dBar slice thickness in bottom zone (defined with "MC21") from 20 to 15 dBar.

CTD sample rank	CTD sample Pressure (raw data) in theoretical slice	CTD sample temperature	CTD sample salinity	Last previous kept sample pressure	Pressure difference with previous sample	Keep after decimation
0	19.9 dBar	17.312	33900	-	-	Yes (1st sample in slice)
1	19.3 dBar	17.314	33901	19.9	19.9–19.3 = **0.6**	Yes
2	18.9 dBar	17.317	33903	19.3	19.3–18.9 = 0.4	No
3	18.6 dBar	17.319	33904	19.3	19.3–18.6 = **0.7**	Yes
4	18.1 dBar	17.320	33905	18.6	18.6–18.1 = **0.5**	Yes
5	17.5 dBar	17.320	33906	18.1	18.1–17.5 = **0.6**	Yes
6	17.1 dBar	17.322	33907	17.5	17.5–17.1 = 0.4	No
7	16.5 dBar	17.329	33909	17.5	17.5–16.5 = **1.0**	Yes
8	16.1 dBar	17.338	33910	16.5	16.5–16.1 = 0.4	No
9	15.6 dBar	17.351	33910	16.5	16.5–15.6 = **0.9**	Yes
10	15.1 dBar	17.361	33913	15.6	15.6–15.1 = **0.5**	Yes

Table 10 - Decimation example

6.14.3 Averaging

All CTD samples kept after decimation are averaged according to slice thickness (zone and thickness) to create a "Treated Data". All the treated Data will be transmit by IRIDIUM.

In our example, following sample pressure will be averaged :

19.9, 19.3, 18.6, 18.1, 17.5, 16.5, 15.6 & 15.1

CTD pressure for treated data is : 18.1375 dBar

Transmitted pressure will be **18.1 dBar**.

CTD temperature sample will be averaged :

17.312, 17.314, 17.319, 17.320, 17.320, 17.329, 17.351, 17.361

CTD temperature for this treated data is : 17.3285 °C

Transmitted pressure will be **17328 m°C**.

CTD salinity sample will be averaged :

33900, 33901, 33904, 33905, 33906, 33909, 33910, 33913

CTD temperature for this treated data is : 33906 mPSU

Transmitted pressure will be **33906 mPSU**.

Example : CTD data kept after decimation for average calculation

CTD sample rank after decimation	CTD sample Pressure (raw data) in theoretical slice, after decimation	CTD sample temperature after decimation	CTD sample salinity after decimation
0	19.9 dBar	17.312	33900
1	19.3 dBar	17.314	33901
2	18.6 dBar	17.319	33904
3	18.1 dBar	17.320	33905
4	17.5 dBar	17.320	33906
5	16.5 dBar	17.329	33909
6	15.6 dBar	17.351	33910
7	15.1 dBar	17.361	33913
Treated Data	**18.1 dBar**	**17.328 °C**	**33906**

For floats equipped with optode, principle is identical for oxygen data (C1ph, C2Ph and optode temperature)

6.15 Parameter data packet (type = 5)

This packet contains float's mission and technical commands.

Data	Nb bytes	Resolution
Type (=5)	1	
General information		
Cycle number	2	1 cycle
Iridium session number	1	
Float time (hh+mm+ss, 1 byte each)	3	hh+mm+ss
Float date (dd+mm+yy, 1 byte each)	3	dd+mm+yy
Float serial number	2	
Mission parameters – Next cycle		
Total number of cycles (MC 0)	2	1 cycle
Number of cycles with cycle period 1 (MC 1)	2	1 cycle
Cycle period 1 (MC 2)	2	Hours
Cycle period 2 (MC 3)	2	Hours
Reference day (MC 4)	1	Day
Expected time at the surface (MC 5)	1	Hour
Delay before mission (MC6)	1	Minutes
CTD sensor acquisition mode (MC 7)	1	
Descent sampling period (MC 8)	1	Seconds
Drift sampling period (MC 9)	1	Hours
Ascent sampling period (MC 10)	1	Seconds
Drift depth used during « MC1 » first cycle (MC 11)	2	dBar
Profile depth used during « MC1 » first cycle (MC 12)	2	dBar
Drift depth used with cycle period « MC2 » (MC 13)	2	dBar
Profile depth used with cycle period « MC2 » (MC 14)	2	dBar
Alternated profile period (MC 15)	1	
Profile pressure of alternated profile (MC 16)	2	dBar
Threshold Surface/Intermediate pressure (MC 17)	2	dBar
Threshold Intermediate/Bottom pressure (MC18)	2	dBar
Surface slice thickness (MC 19)	1	dBar
Intermediate slice thickness (MC 20)	1	dBar
Bottom slice thickness (MC 21)	1	dBar
Iridium End of Life transmission period (MC 22)	2	Minutes
2nd iridium session wait period (MC23)	2	Minutes
Grounding mode (MC24)	1	
Grounding switch pressure (MC25)	1	dBar
Delay after grounding at surface (MC26)	1	Minutes
Optode type (MC27)	1	
CTD Sensor Cut-Off pressure (MC 28)	1	dBar
"In Air" acquisition cycle periodicity (MC29)	1	Minutes
"In Air" acquisition sampling period (MC30)	2	Seconds
"In Air" acquisition total duration (MC31)	2	Minutes
Technical parameters – Next cycle		
Max valve activation on surface (TC 0)	2	1 cs

Max volume of valve action during descent and repositioning (TC 1)	1	1 cm3
Max pump duration during repositioning (TC 2)	1	10 cs
Max pump duration during ascent (TC 3)	1	10 cs
Nominal pump duration during buoyancy acquisition (TC 4)	1	1000 cs
Pressure target tolerance for stabilization (+/-) (TC 5)	1	1 dbar
Max pressure before emergency ascent (TC 6)	2	1 dbar
1st threshold for buoyancy reduction (TC 7)	1	1 dbar
2nd threshold for buoyancy reduction (TC 8)	1	1 dbar
Number of out of tolerance pressures before repositioning (TC 9)	1	
Max volume before grounding detection (TC 10)	1	1 cm3
Min pressure for « shift » grounding mode (TC 11)	1	1 dbar
Pressure target tolerance during subsurface drift (+/-) (TC 12)	2	1 dbar
Average descent speed (TC 13)	1	1 mm/s
Parking pressure increment between cycles (TC 14)	2	1 dbar
Ascent End pressure (TC 15)	1	1 dBar
Average ascent speed (TC 16)	1	1 mm/sec
Pressure check time period during ascent (TC 17)	1	1 min
Vertical threshold for buoyancy action during ascent(TC 18)	1	1 dBar
GPS timeout (TC19)	1	1 min
Hydraulic message transmission (0: no, 1: yes) (TC 20)	1	
Delay before resetoffset (TC 21)	1	1 min
Pump duration for surfacing with “In Air” acquisition (TC 22)	1	1000 cs
Iridium timeout (TC 23) (added in packet from firmware version 5900A02& following)	1	1 min
Descent speed control period (TC24) (added in packet from firmware version 5900A05 & following)	1	1 min
Descent speed control pressure (TC25) (added in packet from firmware version 5900A05 & following)	1	1 dBar
Self test Internal vacuum offset (TC26) (added in packet from firmware version 5900A05 & following)	1	1 mBar
Internal pressure calibration coef A (TC 23) (TC 27)	2	*0,001
Internal pressure calibration coef B (TC 24) (TC 28)	2	* (-1)
Not used (filled by zeros)	6	
TOTAL	100	

Table 11 - Parameters packet

Version YLA5900A05 and higher :
The parameters packets will only be send on the first session before deployment and each times that the float will receive Iridium telecommands.

6.16 Hydraulic packet (type = 6)

These packets contains all information regarding hydraulic activity during the cycle.

Data	Nb bytes	Resolution
Type (=6)	1	
General information		
Cycle number	2	
Cycle beginning relative day	2	1 day
Cycle beginning hour	2	1 min
Actions during cycle		
Hydraulic action #1: type (0: valve, 1: pump)	1	
Hydraulic action #1: hour (relative to cycle beginning)	2	1 min
Hydraulic action #1: pressure (two's complement coded)	2	1 dbar
Hydraulic action #1: duration	2	1 cs
Following hydraulic actions (up to 12)	7*12	
Not used (filled by zeros)	2	
TOTAL	**100**	

6.17 Float parameter n°2 packet (type = 7)

This kind of packet is introduced from firmware version 5900A03 and following.

Data	Nb bytes	Resolution
Type (=7)	1	
General information		
Cycle number	2	1 cycle
Iridium session number	1	
Float time (hh+mm+ss, 1 byte each)	3	hh+mm+ss
Float date (dd+mm+yy, 1 byte each)	3	dd+mm+yy
Float serial number	2	
Ice detection parameters – Next cycle		
Number of days without surface emergence if ice detected (IC 0)	2	1 day
Number of days before surface emergence even with ice detected (IC 1)	2	1 day
Number of detections to confirm ice at surface (IC 2)	1	1 detection
Start pressure detection (IC 3)	1	1 dBar
Stop pressure detection (IC 4)	1	1 dBar
Temperature threshold (IC 5)	2	0.001°C
Slowdown pressure threshold (IC6)	2	1 dBar
Pressure acquisition period during ascent (slow speed), once P < IC6 (IC 7)	1	1 minute
Pressure delta min before pump action (IC 8)	1	1 dBar
Pump action duration (IC 9)	2	0.01 second
GPS timeout (IC 10)	1	1 minute
1st iridium lock timeout (IC 11)	1	1 minute
Delay before ascent blocking detection (IC 12)	1	1 minute

Pressure variation for buoyancy inversion (IC 13)	1	1 dBar
Volume of valve action volume for buoyancy inversion (IC 14)	1	1 cm3
Max volume before grounding detection (while in buoyancy inversion phase) (IC 15)	2	1 cm3
Not used (filled by zeros)	66	
TOTAL	**100**	

Version YLA5900A05 and higher :
The parameters packets will only be send on the first session before deployment and each times that the float will receive Iridium telecommands.

6.18 Life Expiry message

Life expiry messages are transmitted when the float is drifting on the surface and has completed transmission of all data from the last cycle of the mission. Life Expiry mode continues until the recovery of the float or depletion of the battery. Life Expiry messages includes packet type 0, 4, 5 & 7.

These transmissions - unlike other transmissions - occur at "MC22" minutes intervals. The content of the life expiry message is identical to the technical message. This period can be set up to 7200 minutes max (5 days). Minimum recommended value is 5 minutes (only for recovery operations). Period can be set to short period during recovery operations with great care to cost transmission. To reduce float's transmission during End Of Life, this period can be set to high value to decrease transmission cost. End Of Life mode can be set with Iridium commands.

Each mission or technical parameter can be modified with Iridium telecommand. One telecommand file can include up to 10 commands for parameter modification. Several telecommands can be sent for one cycle.

"MC23" Inter-cycles wait period (min) : User sends telecommand that initialize MC23. At each cycle, float waits on surface for MC23 values (minutes). This parameter can be set to zero. Once waiting period ends, float checks if a new telecommand has been sent. If yes, new mission parameter is set with transmitted value and float waits corresponding time. In other case, float begins next cycle.

At following cycle, if no telecommand is sent, float waits programmed value (MC23) set by last telecommand. Telecommand has effect on all cycle.

Technical and mission parameters : new parameters are recovered at each cycle (if telecommand has been sent). So, each new parameter transmitted by telecommand is applied for following cycle.

6.18.1 Phase description

Phase number	Phase Name	Description
0	Pre-mission	Mission beginning
1	Resetoffset	Float sends “resetoffset” command to CTD SBE41 Sensor
2	Buoyancy reduction	Float descending phase at surface (up to TC 8 specific threshold)
3	Descent to parking pressure	Float descends to parking pressure depth
4	Parking Drift	Float drifts at parking depth
5	Descent to profile pressure	Float descends to profile depth
6	Drift at profile depth	Float drifts at profile depth
7	Ascent profile	Float ascends to the surface
8	Satellite transmission	Float transmits all sensor and technical packets
9	Auto-test	Float performs initial auto-test (during prelude phase only)
10	Near Surface	“Near Surface” measurement phase (before float acquires max buoyancy)
11	In Air	“In Air” measurement phase (after float acquires max buoyancy)

Table 12 - Phase number description

6.18.2 Sending a SBD message (telecommand) to the 9602 Iridium modem

Messages can be sent to the 9602 Iridium modem via SBD from almost any e-mail program (Outlook, Outlook Express, etc.).

1. In order to send e-mail messages to a 9602, the e-mail program must use the standard Multipurpose Internet Mail Extensions (MIME) Base64 encoding as defined in RFC 2045. The following instructions describe how to set this up for Microsoft Outlook Express:

a. Select —Tools/Options||

b. Click the —Send|| Tab

c. Under —Mail Sending Format||, click —HTML Settings…||

d. Click MIME

e. Select —Base 64|| for Encode text using

f. Click OK

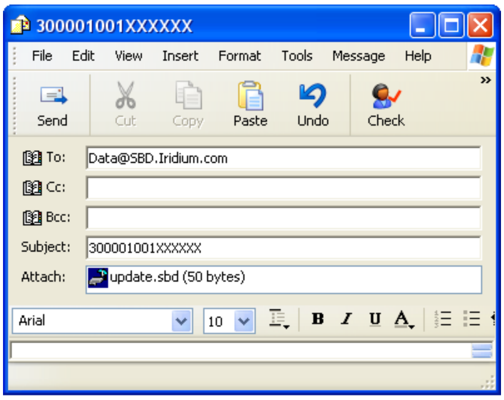
g. Under —Mail Sending Format||, click —Plain Text Settings…||

h. Repeat steps d – f

2. Send all e-mail messages to Data@SBD.Iridium.com

3. Place the IMEI number of the 9602 in the subject line. Be careful to indicate the right IMEI number.

4. The message should be carried in an attachment, which must have a —.sbd|| extension



In a delay of a few minutes, user can check that iridium system send confirmation that message is queued (email coming from sbdservice@sbd.iridium.com with subject : "SBD Mobile Terminated Message Queued for Unit : xxxxxxxxxxxxxxx (here xx replace IMEI number)

Mail from iridium will indicate :

"*The following mobile-terminated message was queued for delivery:*

IMEI: 30003401340xxxx
Time: Thu Apr 29 12:00:13 2010

Attachment Filename: PM0_330.sbd
Attachment Size: 9

The MTMSN is 2, and the message is number 1 in the queue."

At this step, message is queued and ready to be treated by float at next float surfacing.

6.18.3 Telecommand SBD File creation

For example, to modify mission parameter 0 from 300 to 330, user need :

1- to create an empty text file (with notepad or wordpad for example)

2- to type same command as command send to float with hyperterminal. In our example, user need to type in file : !

3- PCM 0 330 followed by carriage return. PC file format (or windows) with CR/LF and ANSI coding must be used, not UNIX or MAC file Format. (UTF-8 coding format). To check if file is properly created, you can check file size (right click on file properties). File size must be equal to all character included in file + 2 (because of non visible character CR/LF).

Example : !MC 0 330 -> 9 characters. So file size must be 11 bytes (9+2)

4- save file as “PM0_330” (This is only an example, any file name can be chose by user, in a limit of 16 characters)

5- close file

6- change file extension from “.txt” to “.sbd”. File name will be “MC0_330.sbd” (Be careful file name is not “MC0_330.sbd.txt” in case file extension do not appears depending on windows configuration).

Once file is created, User must send email to Iridium system, with attached file.

Several command can be included in this file (up to 10). In that case, do not forget carriage return after the last command. If not, this command will not be taken into account

7 SPECIFICATIONS

- Storage

Temperature range.. -20°C to +50°C
Storage time before expiry ....up to 1 year

- Operational

Temperature range... 0°C to +40°C
Pressure at drift depth .... 40 bar to 200 bar
Depth maintenance accuracy .... ± 3 bar typical (adjustable)
Survival at sea ....up to 5 years
Maximum number of cycles...up to 280 cycles

- Mechanical

Length

with antenna ....#200 cm

Diameter

casing ....11 cm
damping disk ....25 cm
Weight..20 kg
Material.. anodized aluminum casing

- Sensors

Salinity

range..0 to 42 PSU
initial accuracy .... ± 0.005 PSU
resolution.. 0.001 PSU

Temperature

range... -3°C to +32°C
initial accuracy ....± 0.002°C
resolution...0.001°C

Pressure

range..0 bar to 2500 dBar
initial accuracy .... ± 2.4 dBar*
resolution..0.1 dBar

Offset adjusted when surfacing

Oxygen

range... .... 0 bar to 500 µM/l
initial accuracy .... ±8 µM/l (if < 160 µM/l) or 5% (if >160 µM/l)
resolution...< 1 µM/l

(*) offset has to be adjusted at each surfacing

8 ARVOR-I OPERATING PRINCIPLE

Movement of the float through its profile is accomplished by a pump and valve system. The pump transfers oil from the inner reservoir to the outer bladder. Oil moves back to the reservoir when the valve is opened- -driven by the difference between the float's internal and external pressures.
The float's speed of ascent oscillates. This oscillation is due to the way in which the float's controller regulates its speed. The controller, using depth measurements from the float's pressure sensor, calculates the change in depth over a set period of time. With this information, the controller determines the float's speed.

When ascending, if the calculated speed is lower than desired, the pump is activated for about 10 seconds, pumping oil into the outer bladder. This produces an increase in buoyancy, which increases the speed of ascent.
As the float rises to shallower depths, its buoyancy decreases, causing the ascent speed to also decrease. When the calculated speed is too low, the pump is activated again.

This cycle repeats until the float reaches the surface.
The same regulating method is used to control the float's descent speed, by opening the valve and allowing oil to flow from the external bladder to the internal reservoir.

Why does ARVOR-I's speed decrease as it ascends?
The buoyancy of a float is determined principally by its mass and its volume, but another factor, hull compressibility, also plays an important role. As ARVOR-I ascends, the decrease in water density reduces the float's buoyancy. At the same time, the decrease in water pressure causes ARVOR-I's hull to expand, which increases the float's buoyancy. The two effects tend to counteract each other.
Because ARVOR-I's compressibility is actually less than that of sea water, the decrease in buoyancy due to decreasing water density is greater than the increase in buoyancy due to hull expansion. This causes ARVOR-I's speed of ascent to decrease as it rises in the water column.
Conversely, as the float descends, the increasing water density increases the buoyancy more than the decreasing buoyancy from hull compression. This causes ARVOR-I's speed of descent to slow as it goes deeper.

To reduce the probability of contact with ships, ARVOR-I's target speed during the initial stage of descent is high at shallow depths. This minimizes the time during which the float is at risk of damage.
To slow the float's descent, its controller is programmed with a series of depths at which the descent speed is halved until it reaches the target depth.

9 LITHIUM BATTERY

All batteries, both lithium and other with chemical elements, contain large quantities of stored energy. This is, of course, what makes them useful, but it also makes them potentially hazardous.

If correctly handled, neither alkaline nor lithium batteries present any risk to humans or the environment. Improper handling of these batteries presents potential risks to humans, but does not present an environmental risk.

The energy stored in a battery cell is stored in chemical form. Most batteries contain corrosive chemicals. These chemicals can be released if the cells are mishandled. Mishandling includes:

- short-circuiting the cells;
- (re)charging the cells;
- puncturing the cell enclosure with a sharp object;
- exposing the cell to high temperatures.

WARNING: BOTH ALKALINE AND LITHIUM BATTERIES MAY EXPLODE, PYROLIZE OR VENT IF MIS-HANDLED. DO NOT DISASSEMBLE, PUNCTURE, CRUSH, SHORT-CIRCUIT, (RE)CHARGE OR INCINERATE THE CELLS. DO NOT EXPOSE CELLS TO HIGH TEMPERATURES.

The lithium thionyl chloride cells used in ARVOR-I floats incorporate sealed steel containers, warning labels and venting systems to guard against accidental release of their contents.

WARNING: IF A BATTERY SPILLS ITS CONTENTS DUE TO MISHANDLING, THE RELEASED CHEMICALS AND THEIR REACTION PRODUCTS INCLUDE CAUSTIC AND ACIDIC MATERIALS, SUCH AS HYDROCHLORIC ACID (HCL) IN THE CASE OF LITHIUM THIONYL CHLORIDE BATTERIES, AND POTASSIUM HYDROXIDE (KOH) IN THE CASE OF ALKALINE BATTERIES. THESE CHEMICALS CAN CAUSE EYE AND NOSE IRRITATION AND BURNS TO EXPOSED FLESH.

The hazard presented by these chemicals is comparable to that presented by common domestic cleaning materials like bleach, muriatic acid or oven cleaner.

Inevitably, the battery contents will eventually be released into the environment, regardless of whether the cells are deliberately dismantled or simply disintegrate due to the forces of nature. Because of their highly reactive nature, battery materials disintegrate rapidly when released into the environment. They pose no long-term environmental threat. There are no heavy metals or chronic toxins in ARVOR-I's lithium cells. Indeed, a recommended safe disposal method for thionyl chloride lithium cells is to crush them and dilute them in sufficient quantities of water.

Discharged batteries pose a greatly reduced threat, as the process of discharging them consumes the corrosive chemicals contained in them.

In summary, ARVOR-I's lithium battery poses no significant or long-term environmental threats. Any threats that they do present, are short-term threats to the safety of persons mishandling the cells. These safety threats are similar to those of other common household-use materials. These threats are reduced when the cells are discharged - and exist only if the cells are mishandled in extreme ways. These threats are the same as those presented by the alkaline cells widely used by consumers.

10 GLOSSARY

BT
Bluetooth

COM1, COM2.
Serial communication ports.

CPU
Central Processing Unit. In the context of ARVOR-I, this term denotes the board that ensures the running and control of the system.

CTD
Conductivity (for salinity), Temperature and Depth

dBar.
1/10 bar = 1 decibar Unit of pressure used for ARVOR-I. It roughly corresponds to a depth of 1m.

IFREMER
Institut Français pour la Recherche et l'Exploitation de la MER (French Institute for the Research and the Exploitation of the Sea).

MC
Measurement code. Unique number assigned to each element of the Argo Trajectory file to code the exact meaning of the stored information.

Mission
The portion of ARVOR-I's life that consists of a number of repeating cycles of descent, submerged drift, ascent and data transmission.

PC
Personal Computer; IBM-PC compatible.

RS232
Widely recognized standard for the implementation of a serial data communication link.

TBD
To Be Defined. This information is not available yet.

Triplet
Set of four measurements (Salinity, Temperature and Depth) all taken at the same time.

Two's-complement
A system for representation of negative numbers in binary notation. The decimal equivalent of a two's-complement binary number is computed in the same way as for an unsigned number, except that the weight of the most significant bit is -2n-1 instead of +2n-1.

VT52, VT100
Video Terminal, type 52 or 100
Computer terminals developed by Digital Equipment Corporation (DEC). They are considered standard in the field.

11 ANNEX A: ACCESS TO DECODED DATA OF ARGO FLOATS

If the float has been deployed within the framework of the Argo project (http://www.argo.ucsd.edu/), the decoded data are available in one of the 4 NetCDF files (META, PROF, TRAJ, TECH) used by the Argo data management to store and diffuse the information (see http://www.argodatamgt.org/Documentation for details).

In the following paragraphs, we describe where each decoded data can be found.

11.1 Cycle number

Cycle number is provided by the float but, depending of float firmware version, the prelude phase (surface drift prior to the first dive) may have the same number (#0) that the first deep cycle.

For the Argo project we decided to assign cycle #0 to the prelude phase, cycle #1 to the first deep cycle and cycle #N (N > 1) to the following ones.

The cycle numbers transmitted by the float may then be modified accordingly.

11.2 Sensor measurements

11.2.1 Argo parameter names

The CTD(O) measurements are stored in the Argo files with a unique variable name.

Sensor parameter	Argo variable name
Pressure	PRES
Temperature	TEMP
Salinity	PSAL
C1Phase	C1PHASE_DOXY
C2Phase	C2PHASE_DOXY
Optode temperature	TEMP_DOXY

11.2.2 Descent profile CTD(O) measurements

Decoded data	Argo file	Argo Variable
CTD(O) profile measurements	PROF	PRES, TEMP, PSAL, C1PHASE_DOXY, C2PHASE_DOXY, TEMP_DOXY
Dated levels of the profile	TRAJ	N_MEASUREMENT variables with Measurement Code = 190

11.2.3 Submerged drift CTD(O) measurements

Decoded data	Argo file	Argo Variable
CTD(O) drift measurements	TRAJ	N_MEASUREMENT variables with Measurement Code = 290

11.2.4 Ascent profile CTD(O) measurements

Decoded data	Argo file	Argo Variable
CTD(O) profile measurements	PROF	PRES, TEMP, PSAL, C1PHASE_DOXY, C2PHASE_DOXY, TEMP_DOXY
Dated levels of the profile	TRAJ	N_MEASUREMENT variables with Measurement Code = 590

11.2.5 “Near Surface” CTD(O) measurements

Decoded data	Argo file	Argo Variable
“Near Surface” CTD(O) measurements	TRAJ	N_MEASUREMENT variables with Measurement Code = 1090

11.2.6 “In Air” CTD(O) measurements

Decoded data	Argo file	Argo Variable
“In Air” CTD(O) measurements	TRAJ	N_MEASUREMENT variables with Measurement Code = 1090

11.3 Technical data

11.3.1 Technical packet type 0

Item #	Argo file	Argo variable	Parameter name
0	-	-	-
1	-	-	-
2	-	-	-
3	-	-	-
4	META	FLOAT_SERIAL_NO	
5 to 7	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_InitialValveActionDescentToPark_YYYYMMDD
8	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_InitialValveActionDescentToPark_FloatDay
9	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_InitialValveActionDescentToPark_HHMM
5 to 9	TRAJ TRAJ	N_MEASUREMENT variables N_MEASUREMENT variables	Measurement Code = 89 Measurement Code = 800 (**of the previous cycle**)
10	TECH	TECHNICAL_PARAMETER_VALUE	TIME_ValveActionsAtSurface_seconds
11	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsAtSurfaceDuringDescent_COUNT
12	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_Beached_NUMBER
13	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_DESCENT_START(N_CYCLE) N_MEASUREMENT variables	CLOCK_StartDescentProfile_HHMM Measurement Code = 100
14	TECH TRAJ	TECHNICAL_PARAMETER_VALUE JULD_FIRST_STABILIZATION(N_CYCLE)	CLOCK_InitialStabilizationDuringDescentToPark_HHMM
15	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_PARK_START(N_CYCLE) N_MEASUREMENT variables	CLOCK_EndDescentToPark_HHMM Measurement Code = 250
16	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsDuringDescentToPark_COUNT
17	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsDuringDescentToPark_COUNT
14 and 18	TRAJ	N_MEASUREMENT variables	Measurement Code = 150
19	TRAJ	N_MEASUREMENT variables	Measurement Code = 198
20	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_EndDescentToPark_DD
21	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_DescentToParkEntriesInParkMargin_COUNT
22	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_RepositionsDuringPark_COUNT

23	TRAJ	N_MEASUREMENT variables	Measurement Code = 297
24	TRAJ	N_MEASUREMENT variables	Measurement Code = 298
25	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsDuringPark_COUNT
26	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsDuringPark_COUNT
27	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_PARK_END(N_CYCLE) N_MEASUREMENT variables	CLOCK_StartDescentToProfile_HHMM Measurement Code = 300
28	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_DEEP_PARK_START(N_CYCLE) N_MEASUREMENT variables	CLOCK_EndDescentToProfile_HHMM Measurement Code = 450
29	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsDuringDescentToProfile_COUNT
30	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsDuringDescentToProfile_COUNT
31	TRAJ	N_MEASUREMENT variables	Measurement Code = 398
32	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_DescentToProfileEntriesInProfileMargin_COUNT
33	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_RepositionsAtProfileDepth_COUNT
34	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsDuringProfileDrift_COUNT
35	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsDuringProfileDrift_COUNT
36	TRAJ	N_MEASUREMENT variables	Measurement Code = 497
37	TRAJ	N_MEASUREMENT variables	Measurement Code = 498
38	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_ASCENT_START(N_CYCLE) N_MEASUREMENT variables	CLOCK_StartAscentToSurface_HHMM Measurement Code = 500
39	TECH TRAJ TRAJ	TECHNICAL_PARAMETER_VALUE JULD_TRANSMISSION_START(N_CYCLE) N_MEASUREMENT variables	CLOCK_TransmissionStart_HHMM Measurement Code = 700
40	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsDuringAscentToSurface_COUNT
41, 42 and 49 to 56	TRAJ	N_MEASUREMENT variables	Measurement Code = 703
43	TECH	TECHNICAL_PARAMETER_VALUE	PRES_SurfaceOffsetCorrectedNotResetNegative_1cBarResolution_dbar
44	TECH	TECHNICAL_PARAMETER_VALUE	PRESSURE_InternalVacuumAtSurface_mbar
45	TECH	TECHNICAL_PARAMETER_VALUE	VOLTAGE_BatteryPumpStartProfile_volts
46	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_RTCStatus_LOGICAL
47	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_CTDError_COUNT

48	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_OptodeStatus_LOGICAL
57	TECH _AUX	TECHNICAL_PARAMETER_VALUE	TECH_FLAG_GPSValidFix_LOGICAL
58	TECH	TECHNICAL_PARAMETER_VALUE	TIME_IridiumGPSFix_seconds
59	-	-	-
60	TECH	TECHNICAL_PARAMETER_VALUE	TIME_PumpActionsAdditionalAtSurfaceForGPSAcquisition_seconds
61	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_AntennaStatus_NUMBER
62 to 64	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_EOLStart_YYYYMMDDHHMMSS

Raw decoding values of cycle timings (time in the day as transmitted in the technical message) are stored in the technical file.

Decoded UTC dates of cycle timings are stored in the trajectory file.

11.3.1Technical packet type 4

Item #	Argo file	Argo variable	Parameter name
0	-	-	-
1	-	-	-
2	-	-	-
3	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_DescentIridiumPackets_COUNT
4	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ParkIridiumPackets_COUNT
5	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_AscentIridiumPackets_COUNT
6	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_NearSurfaceIridiumPackets_COUNT
7	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_InAirIridiumPackets_COUNT
8	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_DescendingProfileReductionUpperPart_COUNT
9	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_DescendingProfileReductionLowerPart_COUNT
10	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ParkCTDSamplesInternal_COUNT
11	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_AscendingProfileReductionUpperPart_COUNT
12	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_AscendingProfileReductionLowerPart_COUNT
13	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_NearSurfaceSamples_COUNT

14	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_InAirSamples_COUNT
15	TECH	TECHNICAL_PARAMETER_VALUE	PRES_LastAscentPumpedRawSample_dbar
15 to 20	TRAJ	N_MEASUREMENT variables	Measurement Code = 599
21	TECH TRAJ	TECHNICAL_PARAMETER_VALUE GROUNDED(N_CYCLE)	FLAG_Grounded_NUMBER
22 to 24	TRAJ	N_MEASUREMENT variables	Measurement Code = 901
23	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeGrounded_FloatDay
24	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeGrounded_HHMM
25	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_FirstGroundingCyclePhase_NUMBER
26	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsForFirstGroundingDetection_COUNT
27 to 29	TRAJ	N_MEASUREMENT variables	Measurement Code = 901
28	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeGrounded_FloatDay
29	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeGrounded_HHMM
30	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_SecondGroundingCyclePhase_NUMBER
31	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_ValveActionsForSecondGroundingDetection_COUNT
32	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_EmergencyAscents_COUNT
33	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeOfFirstEmergencyAscent_HHMM
34	TECH	TECHNICAL_PARAMETER_VALUE	PRES_FirstEmergencyAscent_dbar
35	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsOnFirstEmergencyAscent_COUNT
36	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_TimeOfFirstEmergencyAscent_FloatDay
37	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_RemoteControlMessageOK_COUNT
38	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_RemoteControlMessageKO_COUNT
39	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_RemoteControlCommandOK_COUNT
40	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_RemoteControlCommandKO_COUNT
41	TECH	TECHNICAL_PARAMETER_VALUE	TIME_PreviousIridiumSession_seconds
42	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_IridiumMessagesReceivedPreviousSession_COUNT
43	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_IridiumMessagesSentPreviousSession_COUNT

44	TECH	TECHNICAL_PARAMETER_VALUE	NUMBER_PumpActionsToStartAscent_COUNT
45	TECH	TECHNICAL_PARAMETER_VALUE	PRESSURE_InternalVacuumProfileStart_mbar
46 to 51	TECH	TECHNICAL_PARAMETER_VALUE	CLOCK_LastReset_YYYYMMDDHHMMSS
52	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_InitialCheckError_LOGICAL
53	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_InitialCheckError_NUMBER
54	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_InitialMemoryIntegrityCheck_LOGICAL
55	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_StatusBladderStateAtLaunch_NUMBER
56	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_CTDStatus_NUMBER
57	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_CTDErrorCyclePhase_NUMBER
58	META	PLATFORM_TYPE	
59	TECH	TECHNICAL_PARAMETER_VALUE	FLAG_IceDetected_NUMBER

11.3.2 Hydraulic activity

Valve and pump actions reported through the hydraulic packets (type 6) are stored in the N_MEASUREMENT variables of the:

- TRAJ file for JULD and PRES information,
- TECH_AUX file for JULD, PUMP_ACTION_FLAG, PUMP_ACTION_DURATION, VALVE_ACTION_FLAG and VALVE_ACTION_DURATION information.

within the:

- Measurement Code = 189 for the descent to parking depth phase,
- Measurement Code = 289 for the drift at parking depth phase,
- Measurement Code = 389 for the descent to profile depth phase,
- Measurement Code = 489 for the drift at profile depth phase,
- Measurement Code = 589 for the ascent to surface phase.

11.4 Parameter data

11.4.1 Mission parameters

	Argo file	Argo variable	Parameter name
Mission parameters			
MC 0	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_MaxCycles_NUMBER
MC 1	-	-	*Considered in CONFIG_CycleTime_hours, CONFIG_ParkPressure_dbar and CONFIG_ProfilePressure_dbar*
MC 2 and MC 3	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_CycleTime_hours
MC 4	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_FloatReferenceDay_FloatDay
MC 5	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_SurfaceTime_HH
MC 6	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_DelayBeforeMissionStart_minutes
MC 7	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_CTDPowerAcquisitionMode_NUMBER
MC 8	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_DescentToParkPresSamplingTime_seconds
MC 9	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ParkSamplingPeriod_hours
MC 10	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_AscentSamplingPeriod_seconds
MC 11 and MC 13	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ParkPressure_dbar
MC 12 and MC 14	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ProfilePressure_dbar
MC 15	-	-	*Considered in CONFIG_ProfilePressure_dbar*
MC 16	-	-	*Considered in CONFIG_ProfilePressure_dbar*
MC 17	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureThresholdDataReductionShallowToIntermediate_dbar
MC 18	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureThresholdDataReductionIntermediateToDeep_dbar
MC 19	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ProfileSurfaceSlicesThickness_dbar
MC 20	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ProfileIntermediateSlicesThickness_dbar
MC 21	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ProfileBottomSlicesThickness_dbar
MC 22	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_TransmissionPeriodEndOfLife_minutes
MC 23	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_TelemetryRepeatSessionDelay_minutes
MC 24	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_GroundingMode_LOGICAL
MC 25	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_GroundingModePresAdjustment_dbar

MC 26	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_TimeDelaybeforeDescentRetryWhenStuckAtSurface_minutes
MC 27	META	SENSOR_MODEL	
MC 28	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_CTDPumpStopPressure_dbar
MC 29	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_InAirMeasurementPeriodicity_NUMBER
MC 30	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_InAirMeasurementSamplingPeriod_seconds
MC 31	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_InAirMeasurementTime_minutes

11.4.2 Technical parameters

	Argo file	Argo variable	Parameter name
		Technical parameters	
TC 0	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_SurfaceValveMaxTimeAdditionalActions_csec
TC 1	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_OilVolumeMaxPerValveAction_cm^3
TC 2	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PumpActionMaxTimeReposition_csec
TC 3	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PumpActionMaxTimeAscent_csec
TC 4	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PumpActionTimeBuoyancyAcquisition_csec
TC 5	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureTargetToleranceForStabilisation_dbar
TC 6	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureMaxBeforeEmergencyAscent_dbar
TC 7	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_BuoyancyReductionFirstThreshold_dbar
TC 8	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_BuoyancyReductionSecondThreshold_dbar
TC 9	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_NumberOfOutOfTolerancePresBeforeReposition_COUNT
TC 10	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_OilVolumeMinForGroundingDetection_cm^3
TC 11	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_GroundingModeMinPresThreshold_dbar
TC 12	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureTargetToleranceDuringDrift_dbar
TC 13	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_DescentSpeed_mm/s
TC 14	-	-	*Considered in CONFIG_ParkPressure_dbar*
TC 15	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_AscentEndThreshold_dbar
TC 16	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_AscentSpeed_mm/s
TC 17	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureCheckTimeAscent_minutes

TC 18	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_AscentVerticalThresholdForBuoyancyAction_dbar
TC 19	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_GPSTimeout_minutes
TC 20	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_HydraulicDataTransmission_LOGICAL
TC 21	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PressureOffsetDelayBeforeResetCommand_minutes
TC 22	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_PumpActionTimeBuoyancyAcquisitionForInAirMeasCycle_csec
TC 23	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_ConnectionTimeOut_minutes
TC 24	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	-
TC 25	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	-
TC 26	-	-	-
TC 27	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_InternalPressureCalibrationCoef1_NUMBER
TC 28	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_InternalPressureCalibrationCoef2_NUMBER

11.4.1 Ice detection parameters

	Argo file	Argo variable	Parameter name
Ice detection parameters			
IC 0	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionSpringInhibitionDelaySinceLastIceEvasion_days
IC 1	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionMaxDaysNoTransmission_NUMBER
IC 2	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionConsecutiveDetectionBeforeFloatSurfaceInhibition_NUMBER
IC 3	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionMixedLayerPMax_dbar
IC 4	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionMixedLayerPMin_dbar
IC 5	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetection_degC
IC 6	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_AscentSpeedStartPressureThresholdForSlowPhase_dbar
IC 7	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionPressureInterval_dbar
IC 8	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionAscentVerticalThresholdForBuoyancyAction_dbar
IC 9	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionPumpActionMaxTimeAscent_csec
IC 10	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_GPSTimeout_minutes

IC 11	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionConnectionTimeOut_minutes
IC 12	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionNoVerticalMotionTimeOut_csec
IC 13	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionDescentVerticalThresholdToEndBuoyancyInversionPhase_dbar
IC 14	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionOilVolumePerValveAction_cm^3
IC 15	META	LAUNCH_CONFIG_PARAMETER_VALUE CONFIG_PARAMETER_VALUE	CONFIG_IceDetectionOilVolumeMinForGroundingDetection_cm^3

12 ANNEX B: DETERMINATION OF CYCLE TIMINGS

12.1 Float clock offset determination

Over time, the float's clock may drift. Clock drift can be defined as the drift of the clock in hours/minutes seconds per year. To correct for this, we must apply a clock offset where clock offset is defined as a measurement, done at a given time, of the offset of the clock due to clock drift. Thus a clock offset should be estimated for each cycle and used to correct cycle timings provided by the float.

Float clock offset is defined as: **Float clock offset = Float time - UTC time**.

As ARVOR-I sets its Real Time Clock (RTC) before each transmission phase, the clock offset, which is the drift of the RTC for the cycle duration only, can be neglected. **Float clock offset = 0.**

12.2 Cycle timings determination

The hours and minutes of the cycle timings are obtained from technical message information.

The associated day can be obtained by the following algorithms.

The day of Transmission Start Time (TST) is determined using the time of the first received Iridium message (FMT):

1. Convert FMT in Float Time (FMT_{FT} = FMT + *FloatClockOffset*),
2. Convert the hours and minutes of FMT_{FT} in Technical Message time (in minutes after truncation) to obtain FMT_{FTTM},
3. Compare the resulting FMT_{FTTM} with TST to determine the day of TST (remembering that $FMT_{FTTM} \geq TST$).

The day of Ascend End Time (AET) is determined using TST.

The day of Ascent Start Time (AST) is determined using AET and the assumption that: AET-AST < 24 h.

The day of Deep Park Start Time (DPST) is determined using AST and the assumption that: AST- DPST < 24 h.

The day of Park End Time (PET) is determined using DPST and the assumption that: DPST - PET < 24 h.

The day of Cycle Start Time (CST) is determined using a Reference Date (RD) which can be:

- For cycle #1 (first deep cycle): the day of the first descent (determined from float startup date + PM4),
- For a given cycle #N (N > 1):
  - If cycle #N-1 exists: RD is the time of the last received Iridium message (LMT) of the cycle #N-1,
  - Otherwise, RD is computed from LMT: RD = LMT – CycleDuration (PM1).

The obtained RD is then used to determine the day of CST:

1. Convert RD in float time (RD_{FT} = RD + *FloatClockOffset*),
2. Convert the hours and minutes of RD_{FT} in Technical Message time (in minutes after truncation) to obtain RD_{FTTM},
3. Compare the resulting RD_{FTTM} with CST to determine the day of CST (remembering that $RD_{FTTM} \leq CST$).

The day of Descent Start Time (DST) is determined using CST.

The day part of First Stabilization Time (FST) is determined using DST and the assumption that: FST-DST < 24 h.

The day part of Park Start Time (PST) is determined using FST and the assumption that: FST- PST < 24 h.

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